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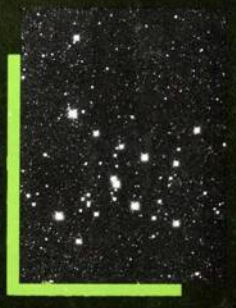

Faint Planetaries near M7

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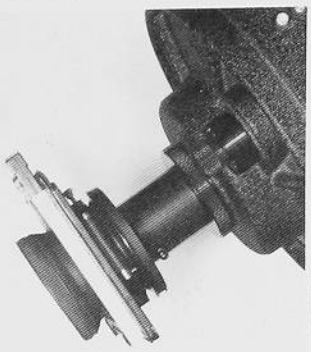

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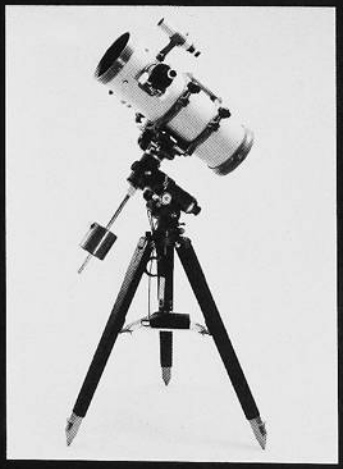

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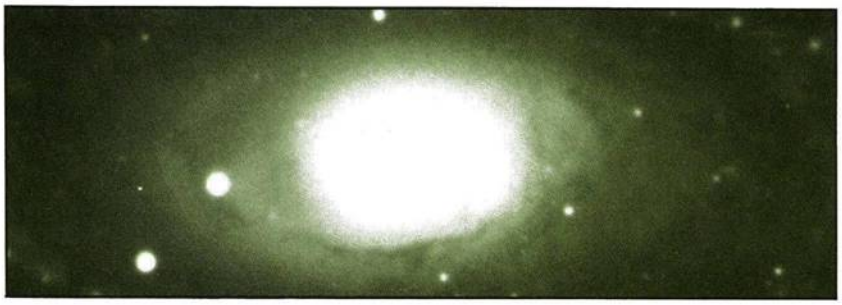
DEEP SKY

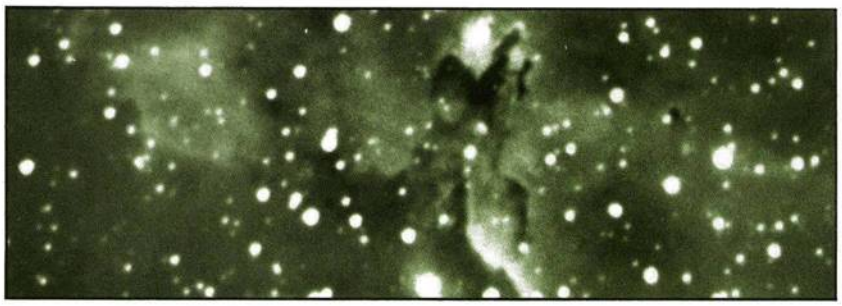
M7 and Its Planetaries
by Jack Marling

10 *Unknown to even experienced backyard observers, some thirty-five faint and challenging planetary nebulae lie within 2° of the great open cluster M7 in Scorpius. This article offers advice on how to spot these elusive nebulae.*



Hints for Prime-Focus Photography
by Rick Dilsizian

18 *More powerful and versatile than piggyback photography, prime-focus (through the telescope) deep-sky photography is the best way to capture nebulae and galaxies on film.*



Deep-Sky Wonders in Ophiuchus, Serpens, and Scutum
by Phil Harrington

24 *The section of sky encompassing Ophiuchus, Serpens, and Scutum is rich in deep-sky wonders. Ophiuchus contains one sixth of the sky's globular clusters. Serpens and Scutum contain open clusters and faint nebulae.*

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THE MAGAZINE FOR
DEEP-SKY OBSERVERS
AND ASTROPHOTOGRAPHERS

Summer 1988
Volume 6, Number 2

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ON THE COVER: The Trifid Nebula photographed by Kim Zussman with an 11-inch f/10 SCT, hypersensitized Tech Pan film, and a 70-minute exposure.

Inside View

Hunting for Faint Planetaries

Texas Star Party, 1988: I stood under the black sky at a borrowed 20-inch telescope owned by Tom Clark of Tectron Instruments and patiently waited. It was early May, and I was being given a tour of obscure planetary nebulae by Jack Marling of Lumicon. "Just a minute, Dave . . . I think I've got Longmore 5 for you. Look in the eyepiece . . . you're probably the second person in the world ever to see this object!"

Whether or not I was the second person to see this object, hunting for faint planetary nebulae is a fun challenge for owners of large telescopes. It gives you the chance to see large, faint disks that are not plotted on run-of-the-mill star charts. It also gives you the chance to see faint stellar planetaries at the limit of detection, identifiable only because they appear slightly brighter when viewed with a filter.

This issue features an article by Jack Marling, who has in recent years become a specialist in observing faint planetary nebulae. One of Jack's interesting discoveries is that thirty-five faint and challenging planetaries lie within just 2° of the bright cluster M7 in Scorpius. The lead feature in this issue provides data, an observing map, and detailed notes on the telescopic appearances of these objects. Jack's sketches of many of the telescopic fields, found on pages 12 and 13, will help you identify these objects at the telescope.

Also in this issue is Rick Dilsizian's second article in a series on deep-sky astrophotography. This installment offers advice on how to do successful prime-focus photography. This is the most powerful technique available for recording faint galaxies and nebulae, yet it is also complicated and can be frustrating. Rick's advice should help refine your techniques to the point where the majority of the exposures you make are successful. Future articles in the series will cover specialized techniques like Schmidt camera photography and film hypersensitization.

The last of the trio of feature articles in this issue details the deep-sky objects of Ophiuchus, Serpens, and Scutum. Rich in Milky Way starfields, replete with globular clusters, these areas of sky contain enough objects to keep you busily observing for a couple of months.

Let me say that I enjoyed meeting a great many *Deep Sky* readers at the Texas Star Party. I am writing this a few days after returning, without enough time to complete a report on the event for these pages. The autumn issue will contain full coverage of the TSP and all the interesting things that happened there.

Congratulations to two *Deep Sky* editors, David H. Levy and Brian Skiff. Levy discovered his fourth comet early this year, and Skiff presented an excellent talk on how to make good observations at the Texas Star Party. (Brian's boss, Jay Gallagher, presented a fine lecture on how little we really know about galaxies.)

One last note: Keep your eye out this summer for a book called *The Universe from Your Backyard*, written by me and published by Cambridge University Press and AstroMedia. It is a collection of articles on deep-sky observing from ASTRONOMY's Backyard Astronomer, and I hope you'll enjoy it.

Dave Eicher
Editor-in-Chief

Letters to DSM

National Deep Sky Observers Society

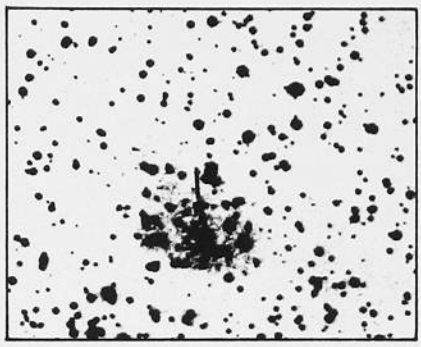
Dear Dave / In the summer 1987 *Deep Sky* you mentioned the National Deep Sky Observers Society. If possible please provide information on membership.

R. C. Amann
23314 Old Valley
Sunnymead, CA 92388

Founded in 1976, the National Deep Sky Observers Society (NDSOS) serves as a clearinghouse for deep-sky observations. The primary means of disseminating information through the NDSOS is our bimonthly newsletter, "Betelgeuse."

Members range from beginners working on observing the Messier list to veteran deep-sky watchers who find 16th-magnitude planetaries, anonymous galaxies, and quasars. We are a friendly, informal group, and encourage all deep-sky observers to join. Membership costs $8 per year. If you have questions about the society's activities, contact me for further information.

Alan Goldstein,
NDSOS National Coordinator
3123 Radiance Road
Louisville, KY 40220



Although in my telescope EGB 1 was visible only intermittently with averted vision, in Jack's 17.5-inch scope it was visible at all times.

I recommend that amateurs interested in new planetaries periodically check the astronomical journals. Planetary nebulae are discovered each year, and although many are extremely faint, some new discoveries are visible in backyard scopes.

Steve Gottlieb
1020 Ramona Avenue
Albany, CA 94706

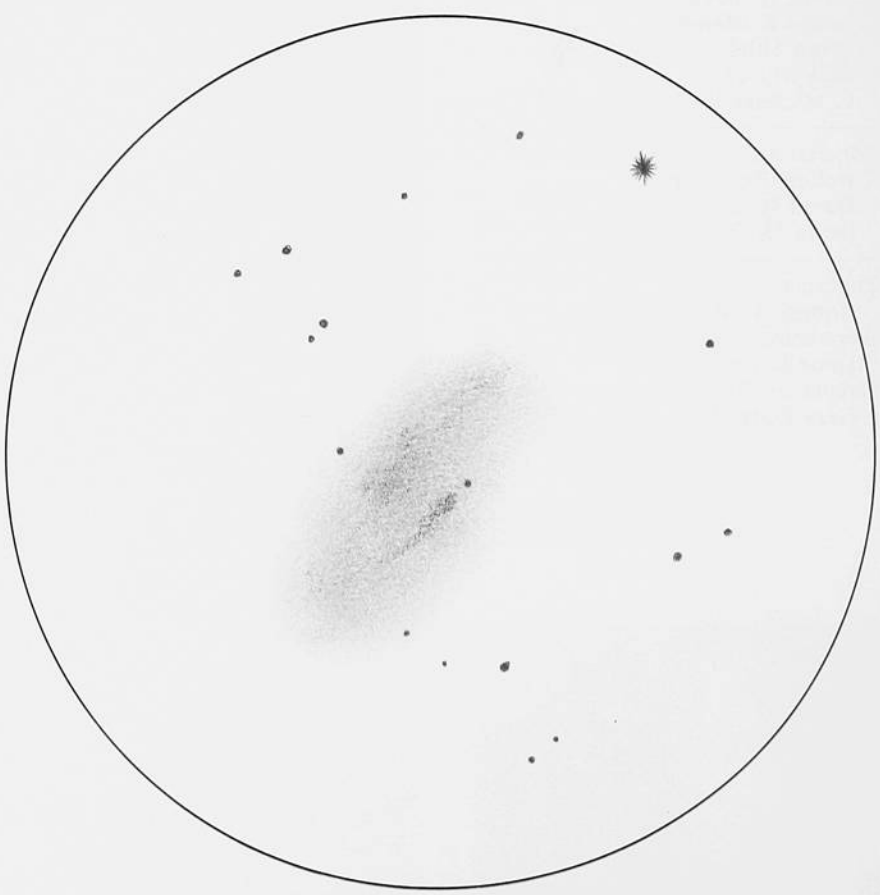
Observing the Crab in OIII

Dear Dave / You and your readers may be interested in an observation I made of a bright OIII region in the Crab Nebula. It lies just southwest of the nebula's center and is tadpole-shaped. I first noticed this feature while sketching the Crab with my 12.5-inch scope at my suburban observatory. At our recent Mount Kaputaar Astrocamp a group of us used a 14.5-inch f/7 telescope with excellent optics at an altitude of 5,000 feet to see if we could detect the feature. It was easily visible with the OIII filter.

I have looked at photographs of M1 in different colors and wavelengths including OIII and cannot see the feature. I'm pretty sure the drawing is accurate, so positional error should not be a factor. The feature was definitely visible to several observers, so there is no risk of a false sighting. Can anyone shed light on what this feature is and why it is not visible in photographs?

Gregg D. Thompson
Springwood Observatory
7 Strover Court

Gregg Thompson made this sketch of the Crab Nebula with a 12.5-inch f/5 reflector at 300x and an O III filter.



Spotting the Elusive EGB 1

Dear Dave / In 1983 researchers Glenn Ellis, Earl Grayson, and Howard Bond of Louisiana State University conducted a most interesting search on the nearly thirty-year-old *Palomar Observatory Sky Survey* (*POSS*) for previously undetected large, low surface brightness planetary nebulae. These nebulae are important to astrophysicists because they represent the oldest known planetary nebulae.

The search technique used by Ellis, Grayson, and Bond was primitive but effective. They held each *POSS* plate at arm's length and examined it for several minutes. Their discovery of seven planetaries was announced in the April 1984 issue of *Publications* of the Astronomical Society of the Pacific. The first object, dubbed EGB 1, lies at 1h7.2m, +73°33′ (epoch 2000.0) and is within reach of large backyard telescopes.

On September 3, 1986, Jack Marling and I tried to spot this planetary from our observing site at Digger Pines, California, east of Mount Hamilton. In my 13.1-inch reflector at 79x I found a fairly large, very faint glow at the nebula's location with an OIII filter. The object measured about 3′ by 2′ and was located between two groups of faint stars to the northwest and southeast.

Springwood,
Queensland, Australia 4127

Sharper Focus, Please

Dear Dave / I noticed some exceptional deep-sky astrophotos in your winter 1987 issue made by Dr. Mike Sisk of Helena, Arkansas. As the builder of his telescope, I would like to make a correction to your caption. The photos were made with a 24.5-inch f/6.2 double aspheric Schmidt-Cassegrain telescope which has a 7-inch-diameter, diffraction-limited flat field at its Cassegrain focus. At least three of the photos were made with a custom 4''-by-5'' vacuum film holder camera with integral off-axis guiding. I look forward to seeing more of his work in your fine periodical.

Jim Riffle
Astro Works Corporation
P.O. Box 86
Cloudcroft, NM 88317

The Sailboat 'Cluster'

Dear Mr. Eicher / While sweeping in Leo Minor with a 4.25-inch RFT, I located a curious group of stars at about 10h10m, +31°30' (2000.0). About 45' across, this asterism contains about ten stars in the shape of a sailboat. After observing the group, I checked the *SAO* and found all of the stars are in the catalogue. *Sky Atlas 2000.0* shows three of the stars and labels the easternmost one 22 Leo Minoris.

Having viewed the group with binoculars, the 4.25-inch RFT, 6-inch and 8-inch telescopes, I find the best views are with the RFT. If the sky is extremely dark or the telescope's field of view too small, the group's sailboat shape becomes difficult to see. Walter Scott Houston informs me that the object was ''great in 15x85 binoculars.''

I have stumbled across many other curious groupings of stars, as I'm sure other readers have. In fact, it is hard not to find circles, lines, and groups of interesting-looking stars. Some observers may find these objects dull, but at the end of an observing session I like to take a look at a few of these asterisms. I would appreciate hearing from readers who have observed this strange object.

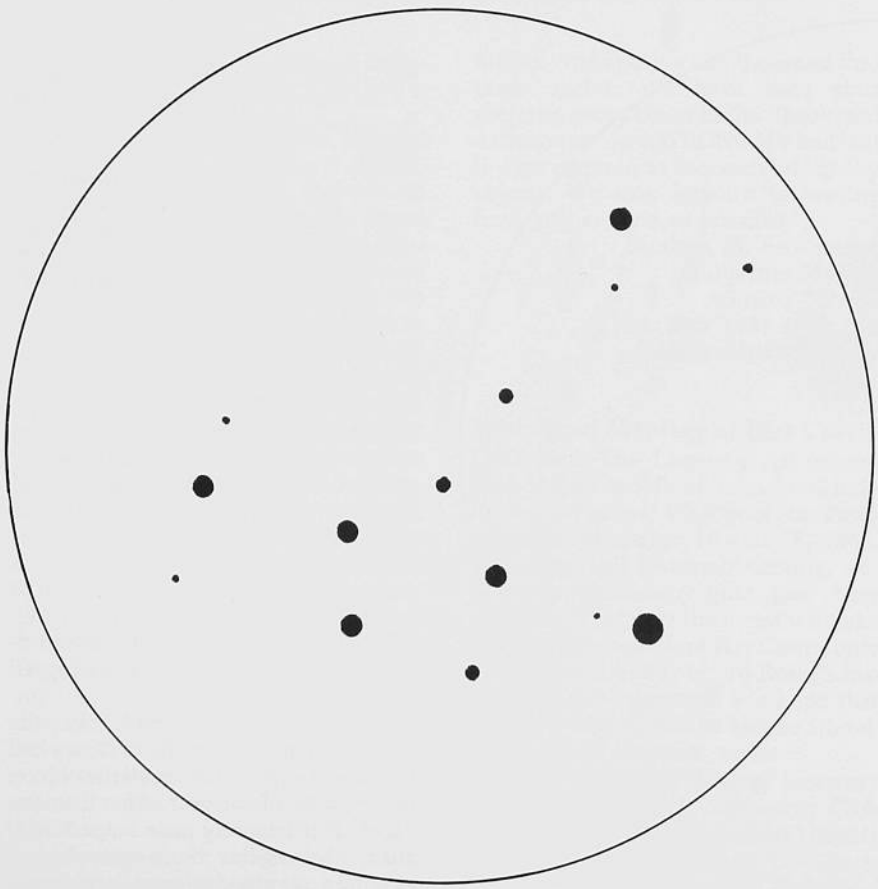
Daniel M. Hudak
3444 Bentwillow Lane
Youngstown, OH 44511

Credit Where It's Due

Dear Dave / My winter *Deep Sky* arrived the other day and I was happy to see my article on variable star observing, which came out very well. Unfortunately, the photos credited to me were taken by William Hubbell of Greenwich, Connecticut. Thanks again for publishing the article.

Gerald P. Dyck
268 Fisher Road
Dartmouth, MA 02747

The ''Sailboat cluster,'' a group of stars in Leo Minor, sketched by Daniel M. Hudak with a 4.25-inch RFT.



Challenging Objects in Monoceros

Dear Dave / I want to thank you and Phil Harrington for the coverage of Monoceros (*Deep Sky*, Winter 1987). I began systematically working through the table on page 18 two nights ago. I found from my drawings that I had previously spotted about half these objects, so I tackled the remainder. The obscure open clusters and emission and reflection nebulae in this constellation are very challenging! The clusters were difficult to spot because I confused them with crowded stellar backgrounds and the nebulae were difficult because they are so faint.

Harrington asked for comments on IC 488, a faint reflection nebula. As stated in his description, the star 13 Monocerotis certainly overwhelms the field containing this object. With an 11-inch Schmidt Cassegrain telescope at 166x I carefully moved the star outside the field and detected a large, extremely faint glow to the west and south. The glow became more perceptible as I moved the declination control up and down.

Last night I completed the list with Berkeley 39, a very faint open cluster barely on the threshold of resolution. The only objects in the list I didn't detect were NGC 2377 (listed in the *RNGC* as nonexistent) and UGC 3964.

On January 25, I was working on some obscure objects in Orion and tried to spot the faint planetary PK 198-6.1, listed in *Sky Catalogue 2000.0* as a magnitude 13.9 object 37'' in diameter. I noticed a bright star in the center of the suspected field and, after checking, discovered it was Mu Orionis. The planetary occupies practically the same position, just a few arcseconds away. The planetary is not plotted on *Uranometria 2000.0*. With the 11-inch scope at 166x and a UHC filter I detected a very faint glow that was not visible without the filter. Can anyone verify the identity of this object?

Lucian J. Kemble
P.O. Box 430
Cochrane, Alberta
Canada T0L 0W0

Mystery Objects from Down Under

Dear Dave / I have more mystery objects for your readers. The region I will describe contains a variety of interesting objects that I invite your readers

to identify as a cloudy night project.

First, picture two stars glowing at about 8th magnitude, almost hiding a faint wisp of irregularly shaped nebulosity. The northernmost star varies erratically in brightness (from about magnitude 8.8 to 12.5), and the nebula varies in brightness and shape. As if that isn't enough, a second nebula lies within the field to the southeast. This nebula is also variable in light output and shape. It looks very much like a comet. The star at the head of this "comet" is an unpredictable variable that fluctuates between magnitudes 11.7 and 13.5.

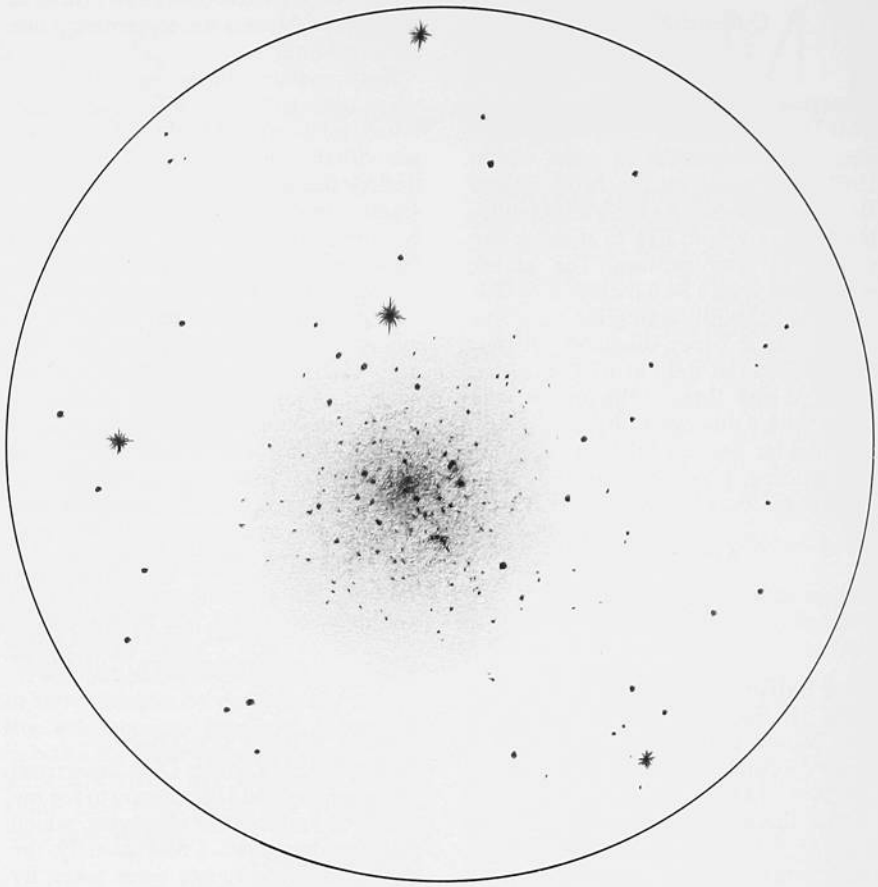
Although the region in which these objects lie is a rich section of the Milky Way, it is devoid of dense background stars because of a large cloud of obscuring dust.

Southwest of and just outside the 13'-diameter field containing the two objects is a beautiful, bright double star with components of magnitudes 6.6 and 6.8.

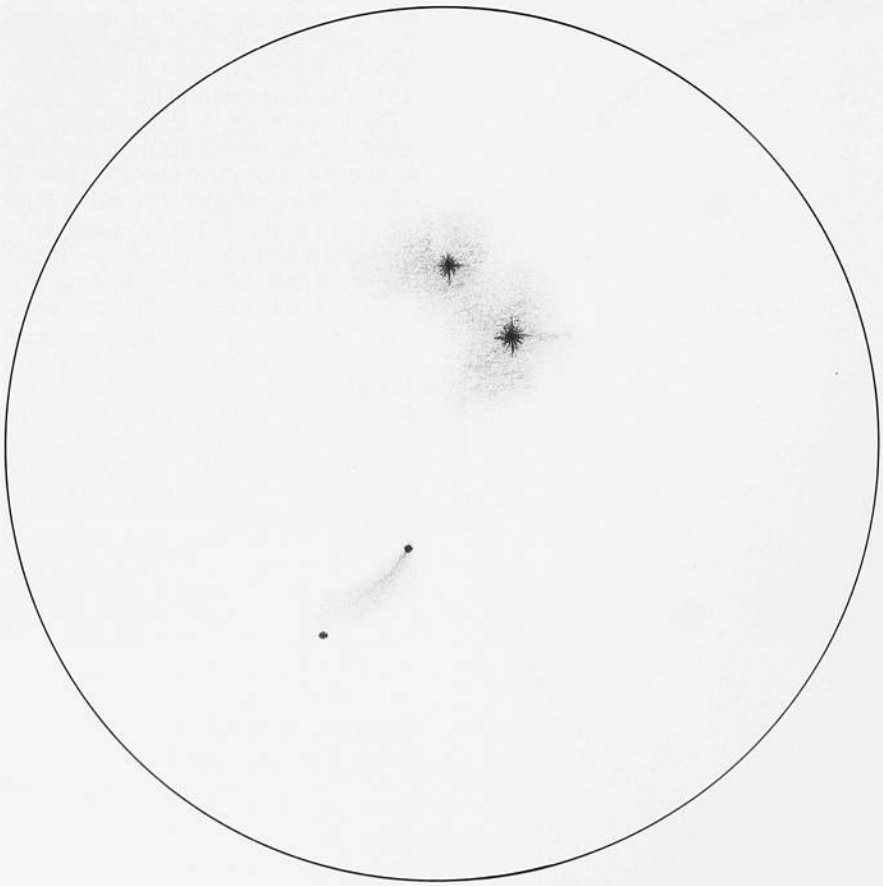
Northwest of the nebulae in the same low power field lies a bright, easily resolvable globular cluster. The cluster lies on the edge of a rich starfield that falls off to the blackness of the obscuring cloud of dust closer to the nebulae.

Can anyone determine the names of these fascinating objects and their positions?

Gregg D. Thompson
Springwood Observatory
7 Strover Court
Springwood, Queensland,
Australia 4127



Mystery object #1: Nebulous region sketched by Gregg Thompson with a 12.5-inch f/5 reflector at 330x. The field diameter is 13' and the view is unfiltered.

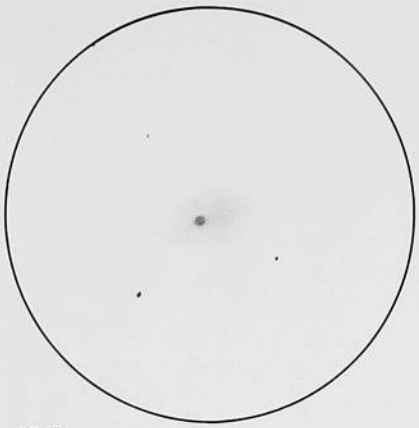


Mystery object #2: Globular cluster sketched by Gregg Thompson with a 12.5-inch f/5 reflector at 300x. The field diameter is 13' and the view is unfiltered.

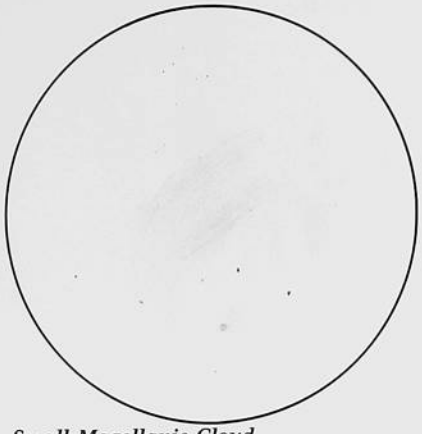
The Messier Marathon Explained

Dear Mr. Eicher / Because there are no Messier objects within 25° of the Sun at the vernal equinox, almost all of them can be seen in a single night during the spring. Only M30 in the dawn sky is considered impossible to see with the others. Seven more are difficult: M74 and M77 in the evening sky and M2, M55, M72, M73, and M75 in the morning sky. Many observers have logged 107 in a single night.

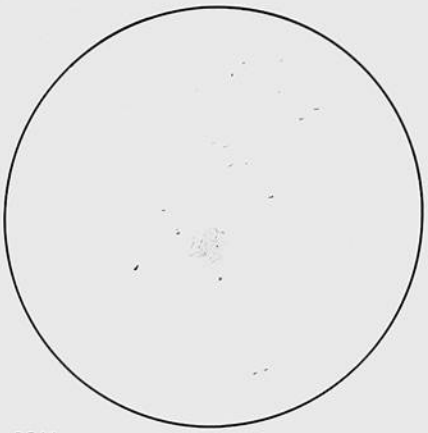
When Tom Reiland and I "ran" the first Messier marathon in 1977, we had both previously observed all the objects in the course of one year rather than one night. This leisurely pace helped us to study the objects thoroughly before making a marathon attempt. In contrast,



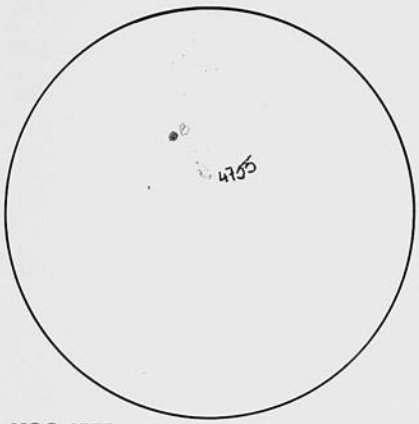
47 Tucanae
60mm refractor at 51x



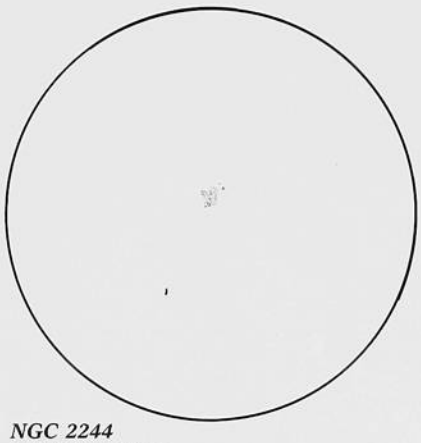
Small Magellanic Cloud
8x40 binoculars



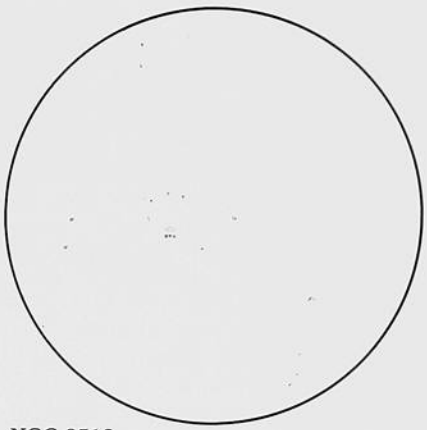
M41
8x40 binoculars



NGC 4755
8x40 binoculars



NGC 2244
8x40 binoculars



NGC 2516
8x40 binoculars

Sketches by Santiago M. de Tezanos, Guillermo Medina, and Bruno Peculio

the marathon was devised as an entertaining project to sharpen our observing skills.

Most people never locate one hundred or more Messier objects in their lifetimes. To do so in one night is an accomplishment anyone can be proud of. It is a unique and rewarding experience, similar to climbing a mountain or running a marathon. And just as with those endeavors, the Messier marathon is not meant for everyone. But those who enjoy an exciting challenge should be encouraged to join the many amateur astronomers around the world who are discovering the good old-fashioned fun of chasing Messier across the heavens.

T. C. Hoffelder
724 Vicksburg Avenue
Norman, OK 73071

Hello from Uruguay!

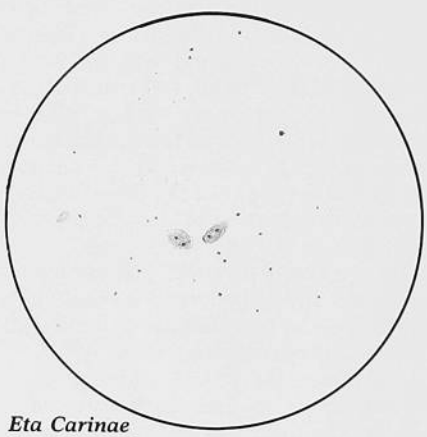
Dear Mr. Eicher / Enclosed please find some of our best sketches of southern deep-sky objects. The instruments we have used to observe the skies are a pair of 8x40 binoculars and a 60mm f/7 refractor. We have ordered a pair of 12x50 binoculars and a 90mm Maksutov telescope so we will be able to make more detailed sketches of the sky in the future. We hope you like these and find them useful. We have seen your sketches many times in the "Backyard Astronomer" in ASTRONOMY and that is what inspired us to observe deep-sky objects. We look forward to hearing from you as soon as possible.

Santiago M. de Tezanos
Guillermo Medina
Bruno Peculio
Fco. Soca 1487 apto. 803
Montevideo, Uruguay

Whirlpool Meeting at Birr Castle

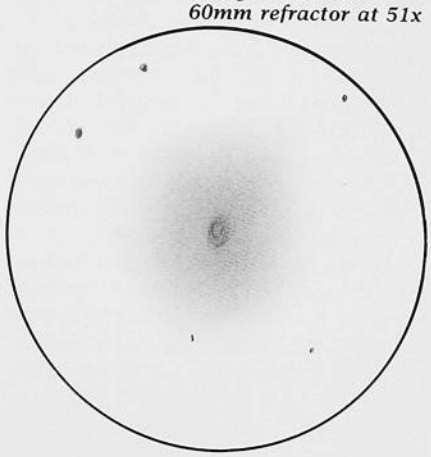
Dear Sir / The Limerick Astronomy Club of the Republic of Ireland will hold the second annual Whirlpool Star Party between September 16 and 18, 1988. The party will feature observing, lectures, an astronomy quiz, and other activities. This year the event will take place on the grounds of Birr Castle, only yards from the site of Lord Rosse's historic 72-inch telescope. We hope that *Deep Sky* readers will be able to attend. For more information, write:

Tony O'Hanlon, Secretary
Limerick Astronomy Club
54 Ballycannon Heights
Meelick, Co. Clare,
Republic of Ireland



Eta Carinae
8x40 binoculars

Omega Centauri
60mm refractor at 51x



M7 and Its Planetaries

by Jack B. Marling

Planetary nebulae are fun to observe. These stellar puffballs come in all sizes and shapes and magnitudes. I've always been an interested observer of planetaries, but I was delighted when Chris Schur told me about a nebula "in" the cluster M7 in Scorpius. It is especially fun to look for pairs of deep-sky objects, so with the help of the sketch Chris sent me, I located Cannon 2-1, a compact, 12th-magnitude planetary 30′ northeast of M7.

Because M7 is located in a rich region of the summer Milky Way, I wondered if any other planetaries could be found in the immediate area. After a bit of detective work I found that thirty-five nebulae existed within a 2° radius of the giant star cluster. However, I came back to reality when I found the fundamental data on these objects. They are not bright planetaries like the Ring Nebula. Nevertheless, using M7 as a bright and convenient starting point, I set out to find as many of these M7 planetaries as possible. In the process I learned that there are also two globular clusters and two small open clusters near M7.

Currently the most comprehensive source of information on planetary nebulae is the *Catalogue of Galactic Planetary Nebulae* by L. Perek and L. Kohoutek, published in 1967 but now out of print. The second volume of *Sky Catalogue 2000.0* lists fifteen planetaries within 2° of M7, but only two have magnitudes listed. Cannon 2-1 is plotted directly on Tirion's *Sky Atlas 2000.0*, as well as on Becvar's *Atlas of the Heavens*. I anticipate that most of these planetaries will be plotted on the second volume of *Uranometria 2000.0*.

My search of the Perek and Kohoutek catalogue and more recent literature revealed that twelve of the thirty-five planetaries had only coordinates listed. Only red surface brightnesses were published for the others but no total magnitudes. Nevertheless, so far I have spotted eighteen of these planetaries.

The Hunt for Objects near M7

Although there are about forty deep-sky objects within 2° of M7, there are only four directly "in" M7, including globular cluster NGC 6453 and planetaries Cannon 2-1, Minkowski 1-30, and Hoffleit 2-1. These objects are not actually inside M7, which lies only 240 parsecs away, but background objects.

The nebulae near M7 are certainly not well known. Some may never have been observed by backyard astronomers. Many of the planetaries near M7 are shown in the accompanying photo by Robert Reeves. Robert made a 10-minute photo of M7 with his 8-inch f/1.5 Schmidt camera, hypered 2415 film, and a #92 red filter. Stars to magnitude 15 are shown. Fundamental data for deep-sky objects in the M7 area are provided in the table, which lists epoch 2000.0 coordinates, size, visual magnitudes (where known), and some brief comments. More detailed comments on each object, including the date it was observed, are given below. I used a 17.5-inch f/4.5 Newtonian telescope owned by the Tri-Valley Stargazers Astronomy Club and placed about thirty miles south of Livermore, California.

Observing the M7 Planetaries

I plot any faint object on star charts before observing it. First I plot the objects on *Sky Atlas 2000.0* and then locate the objects in the telescope by star hopping. With this atlas I usually come within 15′ or 30′ of the object on the first try.

If more precision is needed, I plot objects on the more detailed *Atlas Stellarum*, a photographic star atlas produced by the German amateur astronomer Hans Vehrenberg. On this chart I must remember to use epoch 1950.0 coordinates, but the greater precision of the atlas over *Sky Atlas 2000.0* is a big help. Normally this is enough accuracy to spot an object.

In the case of stellar planetary nebulae, however, using a star atlas isn't enough: you also need to "blink" stellar planetaries with a narrow band-pass nebula filter. Without the filter, a stellar planetary looks like an ordinary star. With the filter in place, though, the planetary becomes brighter and stands out relative to field stars.

When I use an O III filter, I hold the filter just in front of my eye, between eye and eyepiece. Because the filter attenuates stars by about three magnitudes, most dim stars disappear. I generally do this with a high-power eyepiece like a 9mm Nagler and then examine each star that remains in the eyepiece. If the star suddenly seems brighter with the filter in place, it is the planetary I've been hunting.

When I do spot the planetary, I insert a UHC filter into the eyepiece (generally my 9mm or 13mm Nagler) and then estimate the size and magnitude. Next I make a sketch of the starfield so I can find the planetary again. Finally I examine it with the O III filter, estimate its apparent visual magnitude, and then examine it again with an Hβ filter.

Planetaries near M7

Haro 1-29. This is the twenty-ninth object on the first list of newly discovered planetary nebulae published by astronomer G. Haro in 1951. *August 6, 1986:* Stellar object, quite faint, magnitude 15 to 15.5. Invisible in Hβ filter, enhanced by UHC and O III filters. Magnitude and size data unknown.

Minkowski 3-14. *August 6, 1986:* Faint, stellar object enhanced by O III filter but invisible in the Hβ filter. Magnitude is about 15. Size in red light is about 10″ x 5″.

Haro 1-31. *August 6, 1986:* Location examined but planetary not visible. Magnitude and size data unknown.

Haro 1-32. *August 6, 1986:* Faint stellar planetary enhanced by both UHC and O III filters but invisible in the Hβ filter. Estimated magnitude 14 to 14.5. It is visible without a filter and lies in

Martin C. Germano [50mm f/4 lens, hypered Tech Pan film, 25-minute exposure]

The area of sky containing clusters M7 (center) and M6 (upper right) is richly peppered with faint stars, which makes identification of faint planetaries difficult because many of the planetaries are stellar. Photo by John Sanford, made with a 135mm f/3.5 lens, Ektachrome 200 film, and a 9-minute exposure.

the same low-power field as Minkowski 3-14. Magnitude and size data unknown.

Haro 2-21. *August 30, 1986:* Location examined but planetary invisible. Magnitude and size data unknown.

Haro 1-33. *June 12, 1986:* Visible as a magnitude 15.5 stellar object, enhanced by UHC and O III filters. Magnitude and size data unknown.

Haro 2-23. *June 12, 1986:* Extremely faint stellar planetary (about magnitude 15.5) enhanced by O III filter. Magnitude and size data unknown.

Haro 1-35. *June 28, 1986:* Magnitude 13 stellar object with a magnitude 14.5 central star. Although enhanced by the O III filter, this object is also visible in the Hβ filter. The faint planetary Haro 2-23 is located only 4′ west and 1′ north of this planetary.

NGC 6444. Loose open cluster composed of eight stars, the brightest being 11th magnitude.

Haro 1-36. Located 2° south of M7, Haro 1-36 is a 12th-magnitude stellar planetary located 2′ north of the 3rd-magnitude star G Scorpii. Both objects lie 5′ west of the 8th-magnitude globular cluster NGC 6441.

May 22, 1984: Tokuo Nokamoto of Temple City, California, spotted this object with a 14.25-inch f/6 reflector at 130x. He described the object as "easily found, about magnitude 12.5, stellar, no color."

May 26, 1984: Dana Patchick of Culver City, California, spotted Haro 1-36 with his 17.5-inch f/4.5 Newtonian at the 1984 Riverside Telescope Conference. He reported the object as 12th magnitude and stellar.

March 18, 1986: Steve Gottlieb of El Cerrito, California, spotted Haro 1-36 with his 13.1-inch reflector. Gottlieb noted: "Magnitude 12 to 13 'star,' 2′ northwest of bright star. Globular cluster nearby. Obvious improvement with O III filter at 79x."

May 10, 1986: I finally spotted Haro 1-36 at the 1986 Texas Star Party. With a 20-inch telescope I saw the object as a bright stellar planetary with a magnitude of 12.5 to 13.

Stenholm 2-4. Stellar planetary discovered in 1975. Not yet observed, magnitude and size data unknown.

Haro 2-26. *June 18, 1986,* and *July 7, 1986:* Location examined but planetary not seen; magnitude and size data unknown.

NGC 6441. This is a 7th-magnitude globular cluster, 8′ in diameter, located next to G Scorpii and Haro 1-36.

NGC 6453. Strongly reddened, 10th-magnitude globular cluster located 37′ west of M7.

Hoffleit 2-1. *June 12, 1986:* After observing so many stellar planetaries, I found a relatively bright object with a visible disk. This object is the nicest planetary nebula near M7. I estimated its size as 20″ and its magnitude at 13.5 or 14. Hoffleit 2-1 appears round and slightly condensed in its center in an O III filter. It was invisible in the Hβ filter but was visible directly without a filter. Steve Gottlieb estimated this object's magnitude at 14.0.

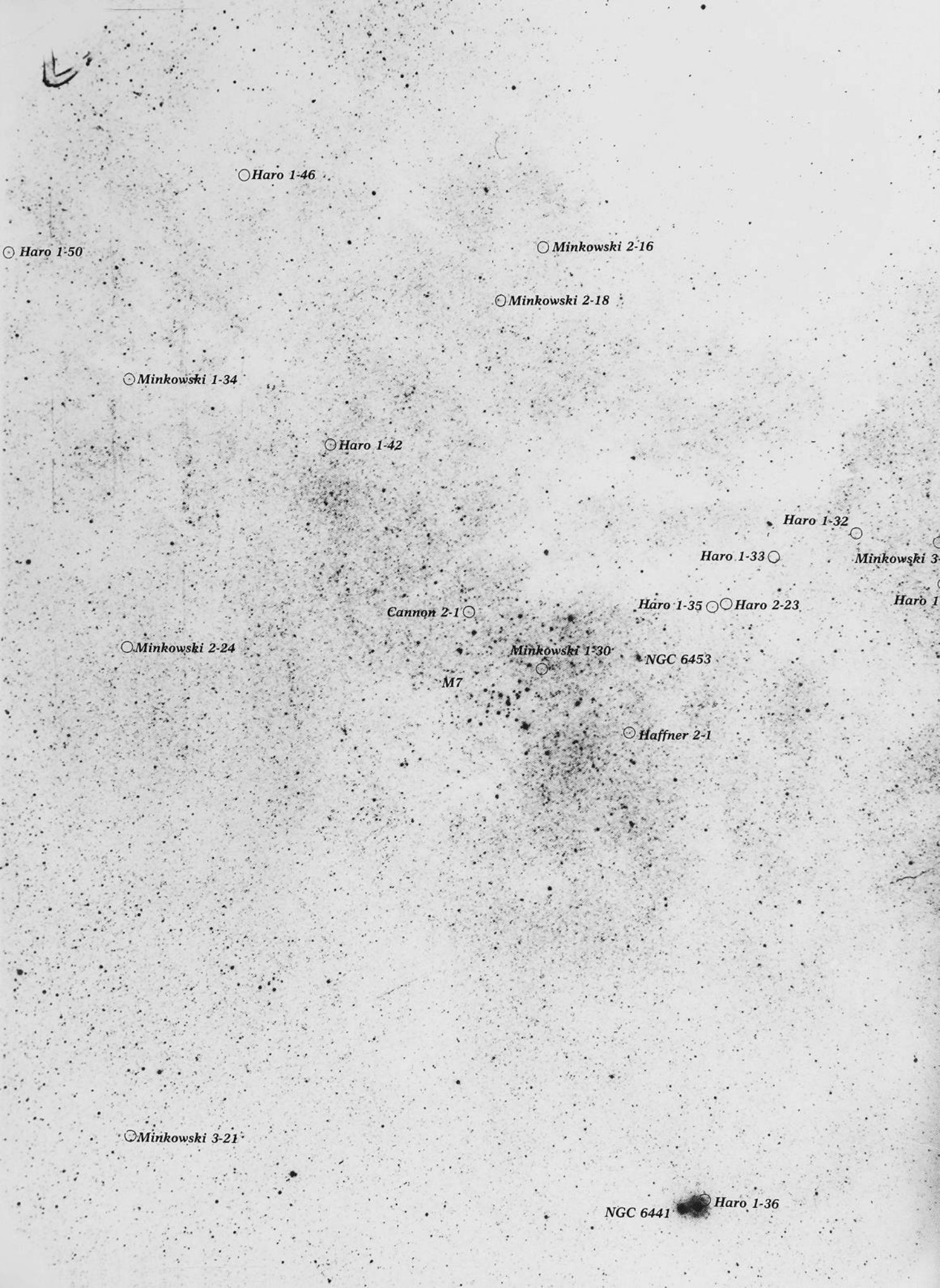
Hoffleit 2-1 illustrates the value of visual observations in this day of high-tech astronomy. The literature reports Hoffleit 2-1's size (measured in red light) as 11″ by 8″, but the planetary was clearly much larger. The only published magnitude data was a surface brightness of 10, again in red light. Based on this, I anticipated seeing a 15th-magnitude object.

However, viewed in the telescope, Hoffleit 2-1 appears quite different. My surmise is that Hoffleit 2-1 has core that appears bright in red light and a faint, larger disk strong in O III emission.

Haro 2-27. *July 7, 1986:* Location examined but planetary not observed. Magnitude and size data unknown.

Minkowski 2-16. *August 30, 1986:* This object appears quasi-stellar at 280x in poor seeing and stellar at 220x. I

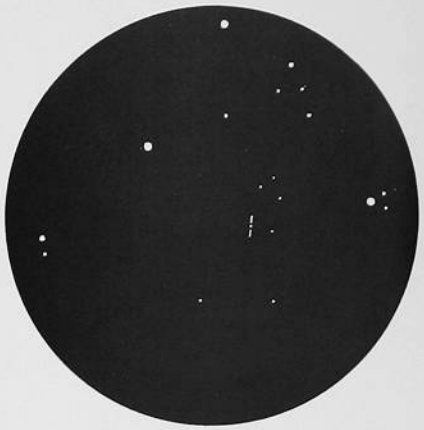
This photograph shows the locations of eighteen planetaries near M7. Photo by Robert Reeves, made with an 8-inch f/1.5 Schmidt camera, hypered Tech Pan film, a #92 red filter, and a 10-minute exposure.


Haro 1-46
Haro 1-50
Minkowski 2-16
Minkowski 2-18
Minkowski 1-34
Haro 1-42
Haro 1-32
Haro 1-33
Minkowski 3
Haro 1
Haro 1-35
Haro 2-23
Cannon 2-1
Minkowski 2-24
Minkowski 1-30
NGC 6453
M7
Haffner 2-1
Minkowski 3-21
NGC 6441
Haro 1-36

The M7 Planetaries in the Eyepiece

All observations by Jack Marling with a 17.5-inch f/4.5 reflector in Digger Pines, California. In each sketch south is up and east to the right.

Cannon 2-1
80x with UHC filter
"Stellar object on northeastern edge of M7; easy to find by blinking."



Haro 1-29
220x with UHC filter
"Stellar, magnitude 15 to 15.5 object; enhanced by UHC, O III filters; invisible in Hβ."

Haro 1-32
220x with UHC filter
"Stellar object visible but faint without filter; enhanced by UHC, O III filters; in same 80x field as Minkowski 3-14."

Haro 1-33
150x with UHC filter
"Stellar nebula glowing at 15th magnitude; enhanced by UHC, O III filters."

Haro 1-35 (upper right) and **Haro 2-23**
150x with UHC filter
"Enhanced by O III filter; visible with Hβ."

Haro 1-36
165x with UHC filter
"Extremely bright stellar nebula just north of bright star adjacent to globular NGC 6441."

Haro 1-42
220x with UHC filter
"Bright stellar object glowing at magnitude 13 to 13.5; enhanced by UHC, O III filters."

Haro 1-46
150x with UHC filter
"Stellar nebula glowing at 14th magnitude; enhanced by UHC, O III filters."

Haro 1-50
220x with UHC filter
"Bright stellar nebula glowing at about magnitude 13.5; nicely enhanced in O III filter."

Hoffleit 2-1
150x with UHC filter
"Easily visible nebula glowing at magnitude 13.5 to 14 and measuring 20" across; 30' west and 10' south of M7; visible in Hβ filter."

Minkowski 1-30
150x with UHC filter
"Faint stellar nebula lying in the middle of M7; barely visible at 280x without filter; enhanced by UHC, O III."

Minkowski 1-34
220x with UHC filter
"Easily seen without filter; 14th magnitude; 10" disk; slightly brighter toward the center; blinks poorly; faint star on northern edge of nebula."

Minkowski 2-16
220x with UHC filter
"Stellar at 200x, quasi-stellar at 280x; magnitude about 14 to 14.5; enhanced by UHC, O III; invisible in Hβ."

Minkowski 2-18
220x with UHC filter
"Faint, compact planetary measuring 5"; enhanced by UHC, O III filters; in same 80x field as Minkowski 2-16."

Minkowski 2-24
220x with UHC filter
"Pretty faint, possibly 15th magnitude; tiny disk, 3" to 5"; enhanced by UHC and O III; invisible in Hβ."

Minkowski 3-21
220x with UHC filter
"Bright stellar nebula; about magnitude 12.5; strongly enhanced by UHC, O III; easily seen without filter."

Planetary Nebulae within 2° of M7

Name	2000.0 Coordinates	Size[a]	Mag.[b]	Comments
Haro 1-29	17h44.23m −34°17.7′	Stellar	15.3	Quite faint, enh. by UHC/O III
Minkowski 3-14	17h44.3m −34°07′	Stellar	15.0	Quite faint enh. by O III
Haro 1-31	17h45.75m −34°31.1′	<5″	?	Loc. examined but PN not seen
Haro 1.32	17h46.10m −34°03.9′	Stellar	14.3	Enh. by O III, in 80x field with M 3-14
Haro 2-21	17h47.42m −32°50.2′	7x3″r	15-18?	Loc. examined but PN not seen
Haro 1-33	17h47.82m −34°08.2′	Stellar	15.5	Enh. by O III Stellar at 280x
Haro 2.23	17h48.96m −34°22.0′	Stellar	15.5	Ext. faint, enh. by O III
Haro 1-35	17h49.23m −34°23.0′	Stellar	13.05	Enh. by O III in field w/H2-23
NGC 6444	17h49.5m −34°49′	12′	?	Open cluster, 8 stars, brightest 11^m
Haro 1-36	17h49.80m −37°01.6′	Stellar	12.12	Bright, just north of a star globular 6441 in field
Stenholm 2-4	17h49.80m −33°31.2′	Stellar		Discov. 1975 — not yet observed
Haro 2-26	17h49.9m −34°02′	5″r	15-17?	Loc. examined but PN not seen
NGC 6441	17h50.2m −37°03′	7.8′	7.4	Glob. near H1-36 not resolved
NGC 6453	17h50.9m −34°36′	3.5′	9.9	Faint reddened globular
Hoffliet 2-1	17h51.2m −34°55′	20″	13.8	Nice disk! round, sl. brighter middle, visible w/o filter, best in O III filter
Haro 2-27	17h51.84m −33°47.7′	?	?	Loc. examined but PN not seen
Minkowski 2-16	17h52.6m −32°46′	5″r	14.2	Quasi-stellar enh. by O III
Minkowki 1-30	17h52.98m −34°38.5′	Stellar	14.9	Faint, in middle of M7, enh. by O III
Haro 2-29	17h53.28m −32°40.8′	4″p	14-16?	Loc. examined but PN not seen
Haro 1-39	17h53.35m −33°56.1′	<5″	?	Loc. examined but PN not seen
Minkowski 2-18	17h53.63m −32°58.9′	5-7″	15.0	Faint compact PN, enh. by O III in 80x field w/M 2-16
M7	17h53.9m −34°49′	80′	3.3	Bright naked-eye open cluster with 30 stars
Cannon 2-1	17h54.58m −34°22.5′	2x3″	12.20	Bright stellar PN NE of M7
Haro 2-30	17h56.22m −32°37.7′	11″r	15-18	Not yet observed
Trumpler 30	17h56.5m −35°19′	10′	?	Lrg. scattered gp., stars mag. 11
Haro 1-41	17h57.3m −34°10′	13x7″r	14-16?	Loc. examined but PN not seen
Haro 1-42	17h57.42m −33°35.8′	Stellar	13.3	Bri. stellar PN enh. by O III
Haro 1-43	17h58.26m −33°47.9′	<25″	?	Loc. examined but PN not seen
Minkowski 2-22	17h58.54m −33°28.7′	6.5″r	14-16?	Loc. examined but PN not seen
Haro 1-46	17h59.04m −32°21.9′	10″	?	Not yet observed, mag. unknown
Sanduleak 3-107	17h59.91m −32°59.3′	?	?	Discov. 1976 — not yet observed
Haro 2-35	18h00.33m −34°27.8′	10″r	15-17?	Loc. examined but PN not seen
Minkowski 1-34	18h01.4m −33°18′	13x10″r	14-16?	Not yet observed
Perek 1-11	18h01.71m −33°15.5′	10x8″r	13-15?	Not yet observed
Minkowski 2-24	18h02.07m −34°27.9′	11x4″r	14.67	Not yet observed
Minkowski 3-21	18h02.54m −36°39.3′	5″	12-14?	Not yet observed
Minkowski 3-49	18h02.5m −35°13′	11x9″r	14-16?	Not yet observed
Haro 1-49	18h03.40m −32°42.5′	<10″	>15?	Loc. examined but PN not seen
Haro 1-50	18h07.09m −32°42′	Stellar	13.5	Bri. stellar PN eh. by O III
Minkowski 3-50	18h04.09m −34°28.8′	7x2″r	15-17?	Not yet observed

[a]The letter "r" after size denotes a size in red light. "P" denotes blue light, visible appearance is not known.

[b]Magnitudes given to one decimal are visual estimates accurate to 0.5 mag., except as noted. Magnitudes to two decimal places are true visual magnitudes determined from photometry.

estimate its magnitude at 14 to 14.5. The view is enhanced by UHC and O III filters, but the object is invisible in an Hβ filter. Minkowski 2-16 lies 2° north of M7.

Minkowski 1-30. This obscure 15th-magnitude planetary is interesting only because it lies right in the middle of M7.

June 6, 1986: Faint, stellar nebula estimated to be magnitude 15 to 15.5. This object is barely visible at 280x without a filter but is enhanced by O III and UHC filters.

July 6, 1986: Dana Patchick used a 17.5-inch f/4.5 reflector to observe this object and described it as "visible at 160x unfiltered without too much difficulty though very faint. Visible steadily at 330x unfiltered. Blinks nicely with O III filter at 330x. Visible with 12.5-inch aperture at 330x, suspected visibility with 10-inch aperture at 330x. Estimated magnitude 13.4 to 14.0."

August 1, 1986: Steve Gottlieb observed Minkowski 1-30 with a 17.5-inch telescope and called it a "very faint 'star' at 222x that forms a triangle with two faint stars to the southeast and northeast. Confirmed by blinking UHC filter. Estimated magnitude 14.5 to 15.0."

Haro 2-29. *August 30, 1986:* Location examined but planetary not observed. Fainter than magnitude 15?

Minkowski 2-16. *August 30, 1986:* Quasi-stellar planetary enhanced by UHC and O III filters but invisible in Hβ filter. Stellar at 220x, quasi-stellar at 280x in poor seeing. Estimated magnitude 14 to 14.5.

Haro 1-39. *June 28, 1986:* Location examined but planetary not observed.

Minkowski 2-18. *August 30, 1986:* Faint, compact object about 5" to 7" in diameter and perhaps about magnitude 15.0. Enhanced by O III and UHC filters. Seeing too poor to confirm disk at high power, so Minkowski 2-18 could be stellar. This object lies within the same field as Minkowski 2-16.

M7. Shining at magnitude 3.3 and containing eighty reasonably bright stars, this large open cluster is an easy naked-eye object. M7 has a diameter of 80', so the best views are at low power. Generally only a portion of M7 is visible through most backyard telescopes.

Cannon 2-1. This 12th-magnitude planetary on the northeast edge of M7 is readily visible in most backyard telescopes. Photometric measurements yield a true visual magnitude of 12.2 for Cannon 2-1; the object is certainly brighter than its photographic magnitude of 13.8. Cannon 2-1 consists of a small disk surrounding a bright central star.

June 14, 1985: Pierre Schwaar observed Cannon 2-1 with his 20-inch telescope at 291x and described it as "very small, about 2" in diameter. The object has a bright central star and blinks (averted vision shows the nebula, direct vision the star). Cannon 2-1 appears stellar at 138x. I estimate its brightness at 10th magnitude, including the star."

Haro 2-30. *June 20, 1987:* Location examined but planetary not observed. Magnitude data unknown.

Trumpler 30. This is a small open star cluster about 10' in diameter.

Haro 1-41. *July 7, 1986,* and *August 8, 1986:* Location examined but planetary not observed. Magnitude data unknown.

Can you spot the planetary nebulae in this photograph? A large telescope will show faint planetaries in Scorpius if you know exactly where to look. Photo by Martin C. Germano, made with an 8-inch f/5 reflector, 103a-F film, and a 15-minute exposure.

Haro 1-42. *July 7, 1986:* Bright stellar nebula enhanced by UHC and O III filters. Estimated magnitude is 13 to 13.5. Barely visible in Hβ filter.

Haro 1-43. *July 7, 1986:* Location examined but nebula not visible. N. Sanduleak (1976) reports weak or nonexistent O III emission.

Minkowski 2-22. *August 30, 1986:* Location examined but planetary not visible. This object should be visible as a small, 14th-magnitude disk. Perhaps the nebula is masked by a bright nucleus.

Haro 1-46. *June 20, 1987:* Stellar planetary glowing at about magnitude 14. Stellar even at 280x.

Sanduleak 3-107. Discovered in 1976; not yet observed, no reported data.

Haro 2-35. *August 6, 1986* and *June 20, 1987:* Location examined but planetary not visible. Magnitude data unknown.

Minkowski 1-34. *June 20, 1987:* Steve Gottlieb observed this object and described it as a "compact object of magnitude 13.2 (±0.2) at 222x without filter. Faint star lies closeby to the northeast. Definitely nonstellar with UHC filter with an 8" disk. Best view was at 286x, has fairly high surface brightness, and brighter center."

July 7, 1987: I looked for Minkowski 1-34 on June 20, 1987, but missed it. After Steve Gottlieb's successful sighting I looked again. This time with a UHC filter I observed a 14th-magnitude planetary at 220x. M 1-34 was invisible with an Hβ filter but was easily seen without a filter. M 1-34 "blinks" very poorly, because it apparently has a 14th-magnitude central star. The disk is 10" in diameter with a slightly brighter middle and faint star on its northeastern edge. The 14th-magnitude central star combined with a 14th-magnitude nebula yields a total magnitude of 13.3.

Perek 1-11. *June 20, 1987:* Location examined but nebula not observed. Magnitude data unknown.

Minkowski 2-24. *June 20, 1987:* Steve Gottlieb observed Minkowski 2-24 and saw it as a "very faint 'star' of about magnitude 14.5 at 220x without a filter. A UHC filter provided a significant gain in contrast. Seeing too poor to discern a disk of less than 6"."

July 18, 1987: I looked for Minkowski 2-24 on June 20, 1987, but missed it. Steve Gottlieb's observation made me try again. This time with UHC filter at 220x I observed a faint nebula glowing at about magnitude 14.7 to 15.0. The object was enhanced by both the UHC and O III filters but was invisible in an Hβ filter. I observed a tiny disk measuring about 3" to 5" in diameter. Based on photometry, the computed visual magnitude is 14.7, in excellent agreement with the visual observations of both Steve and myself.

Minkowski 3-21. *July 18, 1987:* Bright stellar nebula shining at magnitude 12.5 to 13. This object is strongly enhanced by both the UHC and O III filters and bright and easy without a filter.

Minkowski 3-49. *June 20, 1987* and *July 18, 1987:* Location examined but nebula not visible. Magnitude unknown.

Haro 1-49. *August 8, 1986:* Location examined but planetary not visible. This nonsighting is corroborated by N. Sanduleak's 1976 report, which suggests that Haro 1-49 is a Be star, not a planetary nebula.

Haro 1-50. *August 8, 1986:* Bright stellar planetary glowing at magnitude 13.5. Haro 1-49, located 5' west, was not visible.

Minkowski 3-50. *June 20, 1987:* Location examined but nebula not visible. Magnitude unknown.

Deep Sky's editors will look forward to seeing your observations and reports about the faint and challenging planetaries surrounding M7.

An avid watcher of the skies and fan of planetary nebulae, Jack Marling is founder and owner of Lumicon in Livermore, California. He is a frequent contributor to Deep Sky.

Hints for Prime-Focus Astrophotography

by Rick Dilsizian

When deep-sky nuts think of astrophotography, they generally think of prime-focus astrophotography. Photographing through your telescope is the best way to capture the fine details and faint features of galaxies and nebulae at a large image scale.

Prime-focus photography involves attaching your camera to the telescope and letting the telescope act as a giant lens. The method gets the name "prime focus" because no eyepieces or extra lenses help with the process: the optical system consists of the telescope's mirror or lens alone.

Prime-focus astrophotography is rather complicated. It involves a great many things and takes a great deal of practice to produce a perfect prime-focus negative. Although it may be trickier than piggyback photography, prime-focus work pays off with bigger rewards.

Prime-Focus Basics

The first step in prime-focus photography is gathering the right equipment together. In addition to a telescope, you'll need the following items:

1. A motor drive for the telescope.
2. A drive corrector.
3. A guiding eyepiece with illuminated cross hairs.
4. An off-axis guider or separate guidescope.
5. A stool for comfort while making exposures.
6. A camera body capable of long exposures.
7. A coupling ring to attach the camera to the telescope, commonly called a "T ring."
8. A cable release.

In the Winter 1987 issue of *Deep Sky* I outlined the basic methods for astrophotography. First you compose the photograph, then find a guide star within the vicinity to use as a reference for tracking. Next you open the shutter and expose the film.

The telescope's motor drive and drive corrector serve to keep the guide star perfectly centered at the cross hairs of an illuminated reticle eyepiece. Equally as important in the guiding process is a guidescope, either a separate telescope mounted on the main telescope's tube or an off-axis guider. An off-axis guider is a tube that couples to the telescope and, using a prism, diverts a small part of the light from the optical path into a guiding eyepiece.

A cable release is used to lock the camera shutter open, which permits time exposures of deep-sky objects. Most deep-sky objects are dim and require exposures of 10 to 60 minutes to be recorded on film. (More on exposure times later.) When you start an exposure, you'll lock the cable release open and leave it until you end the exposure by closing the cable release.

Never underestimate the importance of comfort for an astrophotographer. A stool is a must for long periods of guiding. The stool should be adjustable because you'll be photographing objects at different elevations in the sky and will need to change the height of the chair.

Telecompressor Magic

Because long exposure times are needed to record faint objects, prime-focus astrophotography can be a tiring process. There's one accessory, however, that can help you cut exposure times without sacrificing the amount of nebulosity you record, a telecompressor. This is a positive lens system that reduces the focal length and effective f/ratio of the telescope/camera.

Let's suppose you get a standard telecompressor, which reduces by a factor of two. An 8-inch f/10 Schmidt-Cassegrain telescope with a focal length of 2000mm would, with the telecompressor, be altered to an 8-inch f/5 SCT with an effective focal length of 1000mm. The immediate disadvantage of a telecompressor is that it reduces the size of the image on a negative by a factor of two.

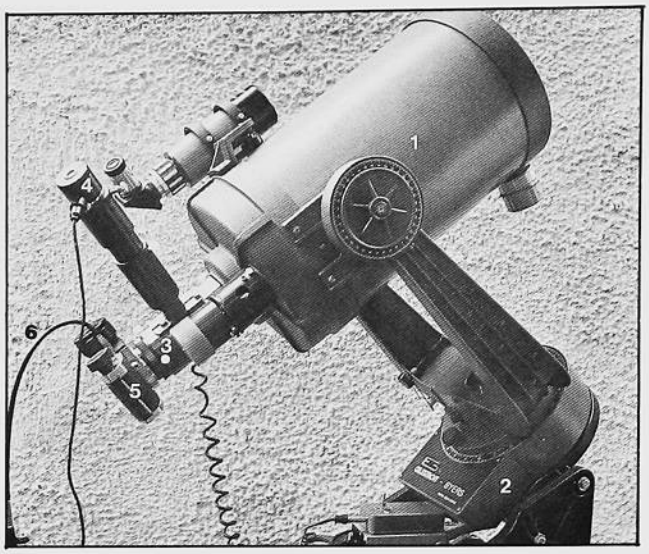
However, the advantage in using a telecompressor concerns image density. The amount of light recorded per unit area is proportional to the square of the f/ratio. This means that an f/5 system records the same image density in one fourth the amount of time required by an f/10 system. If an f/10 system nicely records a deep-sky object in 1 hour, an f/5 system will do it in 15 minutes. Theoretically this is true, but in reality reciprocity failure makes this true only part of the time.

Starting an Exposure

A few things remain before you can start an exposure. To go from being equipped to actually making photographs, you'll have to follow three critical steps in prime-focus work. First, get used to finding guide stars for various fields. Second, practice guiding on both bright and faint stars. Good guiding can only be done after long hours of practice. Third, make sure you can focus your camera accurately.

Unfortunately there aren't always bright guide stars near deep-sky objects. This can be extremely frustrating, because there's nothing much you can do but try to guide on a faint star (and that's often a painful ordeal). A star atlas like *Uranometria 2000.0* or *Sky Atlas 2000.0* will show you some objects with bright guide stars.

When you get ready to make an exposure, center the object you want to photograph in the camera's view finder. Then insert a low-power eyepiece in the



A typical prime-focus astrophotographic rig. Major components are labeled as follows: (1) optical tube assembly; (2) telescope motor drive; (3) off-axis guider; (4) illuminated reticle eyepiece; (5) camera body; (6) cable release. Photo by Rick Dilsizian.

A deep exposure on hypersensitized Tech Pan film was required to capture the faint outer nebulosity surrounding NGC 7635 in Cepheus. Photo by Kim Zussman, made with an 11-inch f/10 SCT and a 120-minute exposure.

guide telescope or off-axis guider. Move the guide telescope or rotate the off-axis guider to find a suitably bright guide star. Center the guide star in the eyepiece, and then insert a high-power, illuminated reticle eyepiece in the guidescope or off-axis guider. If all went well, the object will still be centered in the camera's view finder.

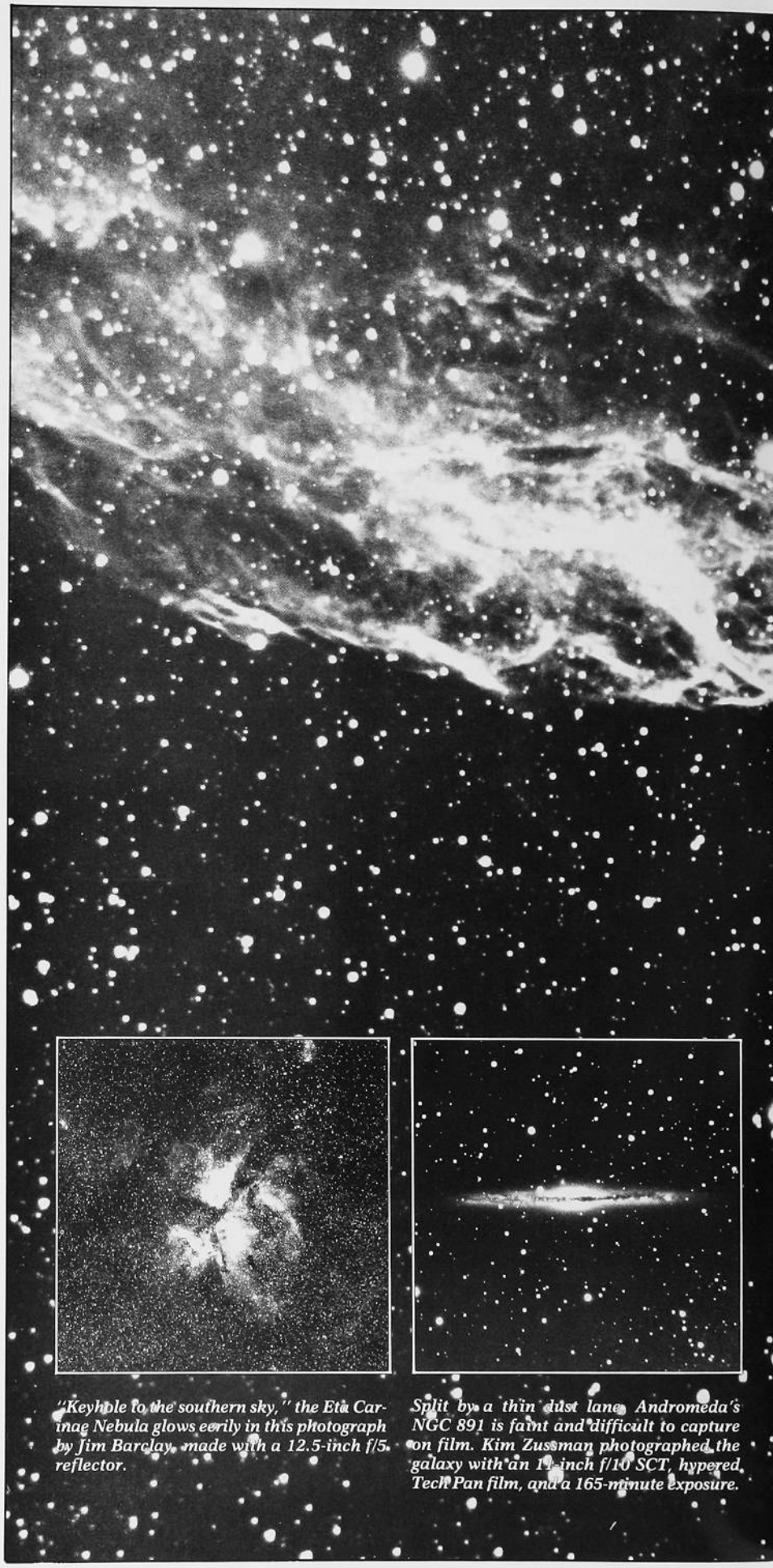
After you get a guide star in sight, what about guiding itself? In prime-focus work the plate scale is large enough that your guiding must be very good or trailed stars will show on the finished negative. If the guide star moves slightly from the cross hairs, it will register as a slight trail on the film. You must have accurate polar alignment and practice guiding enough that you're good at responding to tiny motions of the guide star and recentering it quickly.

One thing that might help is to add a Barlow lens to the guidescope or off-axis guider. This doubles or triples the magnification used for guiding and gives you a little more time to respond to the guide star's motion. You may find that a Barlow lens can be used only when guide stars are bright, because the additional magnification causes the guide star to appear dimmer.

Focusing can be the most frustrating aspect of prime-focus photography. After all, who wants to spend 45 minutes taking a photograph just to find the stars looking like doughnuts because of poor focusing? Several manufacturers make cameras with a focusing mechanism mounted on top of the camera's view finder. These magnifiers are expensive and supply only about 6x or 8x magnification. One of these devices helps but does not ensure accurate focusing. Other cameras have interchangeable focusing screens so the standard ground-glass screen can be removed and a clear screen inserted in its place. *Astrophotography II* by Patrick Martinez suggests a variety of other focusing methods.

One reliable method discussed by Leo Henzl in the late 1970s is excellent for prime-focus work. It is a variation of the knife-edge method using a piece of glass etched with Ronchi lines. To use this method, purchase the glass, called a Ronchi grating, from a company like Edmund Scientific. Glue a 1-inch by 1-inch piece of the grating to an eyepiece cup with the etched part facing down (not glued to the cup). Then go through this procedure:

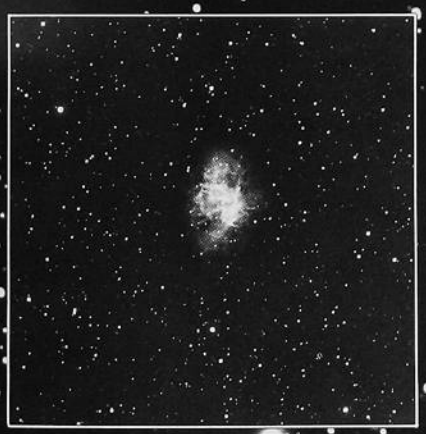
1. With the telescope ready to go but no film in the camera, center a bright star in your camera's view finder.
2. Depress and lock the cable release as if you were going to make an exposure. This will lock the shutter open.
3. Open the back of the camera and place the Ronchi grating flush against



"Keyhole to the southern sky," the Eta Carinae Nebula glows eerily in this photograph by Jim Barclay, made with a 12.5-inch f/5 reflector.

Split by a thin dust lane, Andromeda's NGC 891 is faint and difficult to capture on film. Kim Zussman photographed the galaxy with an 11-inch f/10 SCT, hypered Tech Pan film, and a 165-minute exposure.

Twisting filaments of light highlight this view of the Veil Nebula in Cygnus. To capture such intricate detail, Kim Zussman used an 11-inch f/10 SCT, hypered Tech Pan film, and a 120-minute exposure.



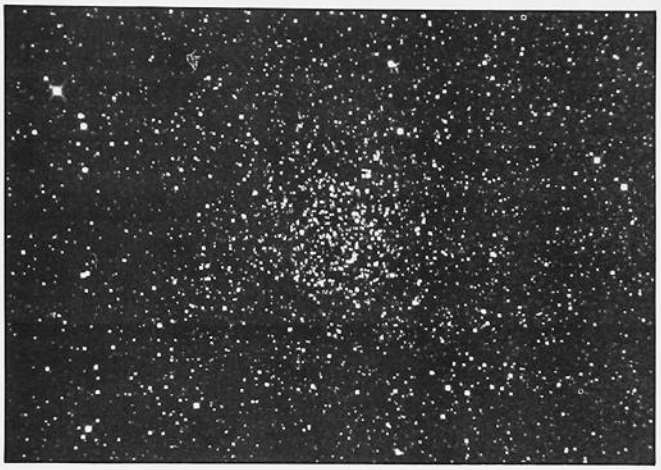
A great favorite of astrophotographers for years, the Crab Nebula in Taurus challenges photographer and telescope to capture tiny rays extending outward from the nebula. Photo by Neyle Sollee, made with a 24-inch f/6.2 double-aspheric Schmidt-Cassegrain scope.

Large but with a low luminosity, the Helical Nebula in Aquarius is one of the sky's most challenging planetary nebulae. Martin C. Germano captured it with an 8-inch f/5 reflector, hypered Tech Pan film, and a 45-minute exposure.

Thousands of stars gleam in this photo of M13 in Hercules. Photo by Jack Marling, made with a 10-inch f/5 reflector, hypered Tech Pan film, and a 15-minute exposure.

Composed of hot stars in its center and an enormous wreath of nebulosity peppered by dark globules, the Rosette Nebula in Monoceros is one of the sky's great showpieces. Photo by Tom Dey, made with a 12.5-inch f/6.1 reflector, hypered Tech Pan film, a 240-minute exposure, and an Hα filter.

NGC 7789 is a large, scattered group of several hundred stars in Cassiopeia. Martin C. Germano's photograph approximates the view of NGC 7789 through a small telescope at low power. Germano used an 8-inch f/5 reflector, 103a-F film, and a 10-minute exposure.



A Typical Prime-Focus Exposure

What's the typical method for making a prime-focus deep-sky astrophoto? Here's the blow-by-blow.

1. Attach all the astrophotographic components and accessories you'll need to the telescope.
2. Align the telescope accurately on the north celestial pole.
3. Find the deep-sky object you want to photograph and compose the field through your camera's view finder.
4. Insert a low-power eyepiece in the guide telescope or off-axis guider.
5. Move the guidescope or rotate the off-axis guider to find a bright guide star. Once found, insert the high-power illuminated reticle eyepiece.
6. Remembering the camera's position, momentarily move the telescope to the bright guide star. Focus the camera.
7. Load the camera with film.
8. Move the telescope back to the object. Your guide star should return to the illuminated reticle eyepiece.
9. Rotate the illuminated reticle so the cross hairs follow right ascension and declination. To do this, turn the drive motor off and the watch the guide star drift. Move one of the cross hairs parallel to the drift, and you'll be aligned.
10. Make sure the camera is set on "B" or "T" for a time exposure.
11. Slowly depress the cable release while viewing the guide star to make sure the star doesn't drift as you start the exposure. The exposure is now running.
12. At the end of the exposure, release the locking mechanism on the cable release to close the shutter.
13. Advance the film and get ready for another exposure.

the film tracks in the camera.

4. Look through the glass. The Ronchi lines will appear to be parallel lines against the bright star's image.

5. Focus the telescope so one of the Ronchi lines fills the lit area of the bright star. This means you are nearly at perfect focus.

6. Move the glass on those inner tracks in the camera. If the line against the star moves in the same direction that the glass moves, you are inside the actual focus. If the line moves in the opposite direction as the glass, you are outside of focus. Once no movement can be detected (in Henzl's words, when "the beam appears to darken uniformly from both directions"), you have precisely focused the camera.

7. Load the film and begin an exposure.

Remember that precise focusing can change slightly with temperature. Recheck the telescope/camera focus with this test about once every hour. This means you will be able to take about two or three negatives, rewind the film back to the film leader strip, recheck the focus, and reload and advance the film to the point of the next exposure. Or detach the camera, cut the exposed film off the roll, and load it onto a processing reel for development. Then go back outside, refocus, and reload the film.

Films and Exposure Times

Because of the long exposure times needed in prime-focus photography and reciprocity failure, I strongly recommend gas-hypersensitized Tech Pan 2415 for deep-sky photography. If you want to shoot color negatives, try hypersensitized Konica SR 400 or SRV 1600. If you want color slides, try hypersensitized Fujichrome 100 or Ektachrome 400.

Sky conditions determine the optimum exposure time for photographing various objects. Stellar objects like open and globular clusters generally require less time than nebulae. High surface brightness planetaries can be recorded very quickly. Galaxies require the most time of all because their faint outer envelopes have extremely low surface brightnesses.

A good rule of thumb is to take the f/ratio of the system, square it, and use that figure in minutes. If you have an f/5 system, use 25 minutes as a starting point and experiment from there. If your system operates at f/7, start at 50 minutes. You can make adjustments from this rule based on your sky conditions and what you're shooting.

Remember that whatever you photograph and however much time you spend to get your system running, try to have fun. A complicated process like prime-focus photography will throw many curves at you and you'll invariably end up with a pile of film on the darkroom floor, ruined from something or other. Don't let that get you down. Everyone who photographs deep-sky objects goes through the same traumas, and there's only one way to win — with persistence.

Rick Dilsizian is an assistant professor of mathematics at Westchester Community College in Valhalla, New York. He is a frequent contributor and is known for his excellent astrophotos.

Further Reading

The following sources contain much information about prime-focus photography and examples of prime-focus photographs.

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Deep Sky Wonders in Ophiuchus, Serpens, and Scutum

by Phil Harrington

The expanse of sky containing Ophiuchus, Serpens, and Scutum is a bountiful hunting ground for backyard astronomers. Many fine examples of every type of deep-sky object are hidden in this area, waiting to be hunted down and viewed by backyard astronomers.

As we peer toward Ophiuchus, our gaze skirts the core of the Milky Way. It is not surprising to find this area littered with glimmering globular clusters hovering about our galactic nucleus. Each cluster contains from 100,000 to over 1 million stars within its gravitational hold.

From studying the spectra of these stars, astronomers conclude that globulars consist of old Population II stars. Further detailed investigations reveal that all of them formed at roughly the same time as the Milky Way, about 15 billion years ago. Globular clusters are among the oldest structures in the universe.

Two of the most readily identifiable globulars in Ophiuchus are **M10** and **M12**. Both lie nearly centered within this constellation's large, hexagonal body. Charles Messier discovered them both in May 1764 and described each as a "nebula without stars."

That statement says more about the quality of Messier's telescopes than it does about the clusters. Today's 4-inch telescopes should begin to resolve the stars of M12. The brightest are magnitude 12, with their combined light roughly equal to a 7th-magnitude star. M12 is a Class IX globular, which indicates a fairly loose stellar structure. Globulars are classed on a 12-step scale depending on their apparent density. Class I clusters are very tightly packed, while Class XII are loose. All other things being equal, less compact globulars are generally easier to resolve than their close knit counterparts.

Neighboring M10 is nearly identical to M12. A good 6-inch starts to resolve this cluster. Catalogued as a Class VII cluster, M10 is 4.4 kiloparsecs away, at about the same distance as M12. The two clusters are not neighbors, with 1.1 kiloparsecs lying between them.

Draw a line from Beta to Eta Ophiuchi. About halfway between is a 4th-magnitude star, 47 Ophiuchi. Center your telescope here, and look along the eastern edge of the eyepiece's field. **NGC 6366** should be in the eyepiece. NGC 6366 is a small, 9th-magnitude globular. Its faint stars are loosely concentrated, and some are visible in a 16-inch telescope.

IC 1257 is a mysterious object located due south of NGC 6366. The *Skalnate Pleso* refers to it as an open cluster, but Robert Burnham's *Celestial Handbook* suggests that it might be a remote globular cluster. Whatever its true nature, IC 1257 is faint. I have failed to see it in an 8-inch f/7 Newtonian under nearly ideal conditions. When conducting a search for it, bear in mind that the object is only 1′ in diameter and is easily passed over. What is the smallest telescope that will show this object?

You will find **M14** far more rewarding. This 9th-magnitude globular cluster is set in a star-poor region of eastern Ophiuchus. William Herschel was the first to recognize M14's cluster appearance. Small backyard telescopes show M14 as a featureless glow. A mottled texture was visible in my 8-inch scope, but at least a 10-inch telescope is needed for resolution. The brightest stars of M14 glow at only 14th magnitude.

Tucked between Nu and Tau Ophiuchi is globular **NGC 6517**. Though listed as 12th magnitude in some catalogues, NGC 6517 actually glows at 10.5-magnitude. Resolving this cluster will have to be left to bigger scopes, because NGC 6517's stars are quite faint.

Now cross into Serpens for a moment to view **NGC 6539**. This is another faint globular that is not well known. Most instruments show an amorphous glow with only the slightest central brightening.

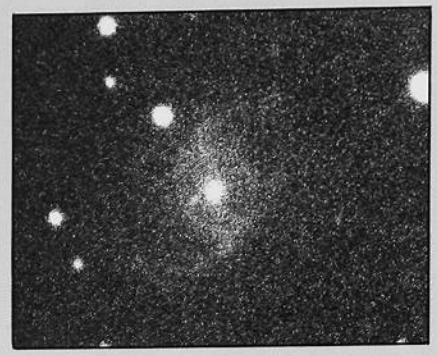
Heading northward, we close in on Beta Ophiuchi. Using binoculars or a finder scope, center on Beta and look to the northeast. Do you see a huge open cluster? That's **IC 4665**, a 4th-magnitude group with a diameter equaling that of two Full Moons. IC 4665 may be viewed with the unaided eye on dark, clear nights, and even the slightest optical aid will show its two dozen 7th-magnitude stars.

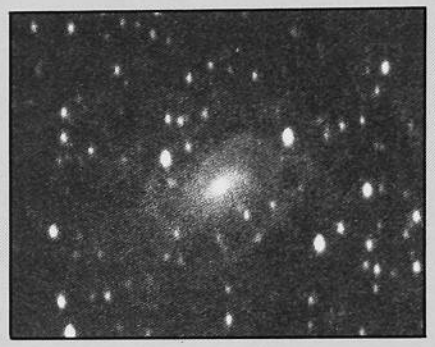
Look just south of Beta to find **NGC 6426**, a faint globular. At Stellafane a couple of years ago I saw this cluster as a moderately large, unresolved glow in my 8-inch scope. A 12-inch telescope is probably the smallest to resolve it.

About 3.5° east of Beta Ophiuchi is **Barnard's Star**. Appearing as a 9th-magnitude object, it was discovered by E. E. Barnard in 1916. Barnard compared photographic plates taken twelve years apart and noted the star's large proper motion. Barnard's Star is moving almost due north relative to the background stars at a rate of 10.29″ per year. This is the largest proper motion of any known star. At a distance of 1.8 parsecs, this M5 red dwarf is the second closest star to the Sun.

Both Tirion's *Sky Atlas 2000.0* and Burnham's *Celestial Handbook* contain maps showing Barnard's Star and its path. An interesting activity would be to accurately draw or photograph its field, wait a few years, and do it again. The star's movement against the background would be visible after such an interval.

NGC 6572 will make a nice addition to your list of planetary nebulae. Look





Clockwise from above: NGC 6027 is a faint group of galaxies in Serpens. Photo by K. Alexander Brownlee. NGC 6633 in Ophiuchus contains thirty stars of 8th magnitude and fainter. Photo by Martin C. Germano. Serpens' NGC 5921 is an 11th-magnitude barred spiral. Photo by Ron Potter. The only bright galaxy in Ophiuchus is NGC 6384. Photo by Bill Iburg.

for a fairly large, oval disk that is distinctively blue. At 8th magnitude, even a 3-inch scope should be able to show the nebula. Larger scopes will show its 13.6-magnitude central star. About 4° to the northwest is another planetary, unlabeled on the *Sky Atlas 2000.0*. **Cannon 3-1** is a 12th-magnitude planetary measuring about 6" across, which makes it readily identifiable with 6- to 8-inch instruments at high power. There is little additional information on Cannon 3-1 in any of the popular literature for observers. Readers are encouraged to send along reports of sightings for publication.

Open cluster **NGC 6633** can be found near the Ophiuchus/Serpens border. Its 5th-magnitude light is detectable with the naked eye under good sky conditions, and binoculars will beautifully display most of its members. When viewing NGC 6633, be sure to use your widest-field eyepiece, or the cluster's fringes will spill out of view.

Before moving on to another target in Ophiuchus move eastward into Serpens, this time for a look at **IC 4756**. Because this cluster is enormous, a rich-field telescope, binoculars, or a finder is a good choice for the best view. My 4.25-inch f/4 RFT reveals over fifty stars gleaming at 7th magnitude and fainter. Both NGC 6633 and IC 4756 are nice objects for observers new to deep-sky observing.

A lone bright galaxy can be found within Ophiuchus. **NGC 6384** is a magnitude 10.6 spiral. An 8-inch shows it as an oval glow measuring about 4' by 3' with a distinct central brightening.

Turning southward, you'll find that the lower portion of Ophiuchus is really where the action is. As you near the galactic core, the number of deep-sky objects increases dramatically.

M107 is a frequently ignored globular cluster located south of Zeta Ophiuchi. An 8th-magnitude object, M107 appears as a faint, diffuse glow in 4- to 6-inch instruments, while 8- to 10-inchers show a grainy surface with a few faint stars visible. A 12.5-inch scope shows the component stars quite nicely.

Just north of Eta Ophiuchi is **NGC 6309**. A 4-inch telescope is capable of showing this magnitude 11.5 planetary nebula. Medium or high magnifications will reveal two faint stars seemingly embedded in the nebula along its major axis. These stars, however, are probably clumps of nebulosity or faint field stars: the central star glows dimly at magnitude 13.7.

M9 is the brightest in a trio of globular clusters between Eta and Xi Ophiuchi. About 6.9 kiloparsecs from Earth, M9 shines with the light of an 8th-magnitude star spread over a 9' diameter. Moderate-size amateur instruments begin to detect individual stars around the fringes, and a high powered 12- or 13-inch scope gives a startling view.

Just over a degree northeast of M9 is **NGC 6356**. It is nearly a twin to M9, measuring 7' across at magnitude 8, but it remains unresolved in small telescopes even at high power. The third cluster in this small triangle is **NGC 6342**. The difficult double star ADS 10476 (magnitudes 6.5 and 14, separation 5.1") lies just to the northwest and is a good landmark to look for when star hopping. NGC 6342 is the only 10th-magnitude unresolved glow in an 8-inch scope, but I have heard reports of individual stars observed with a 10-inch scope. All three clusters lie within 2° of each other and may just squeeze into the single eyepiece field of a very short focal length instrument.

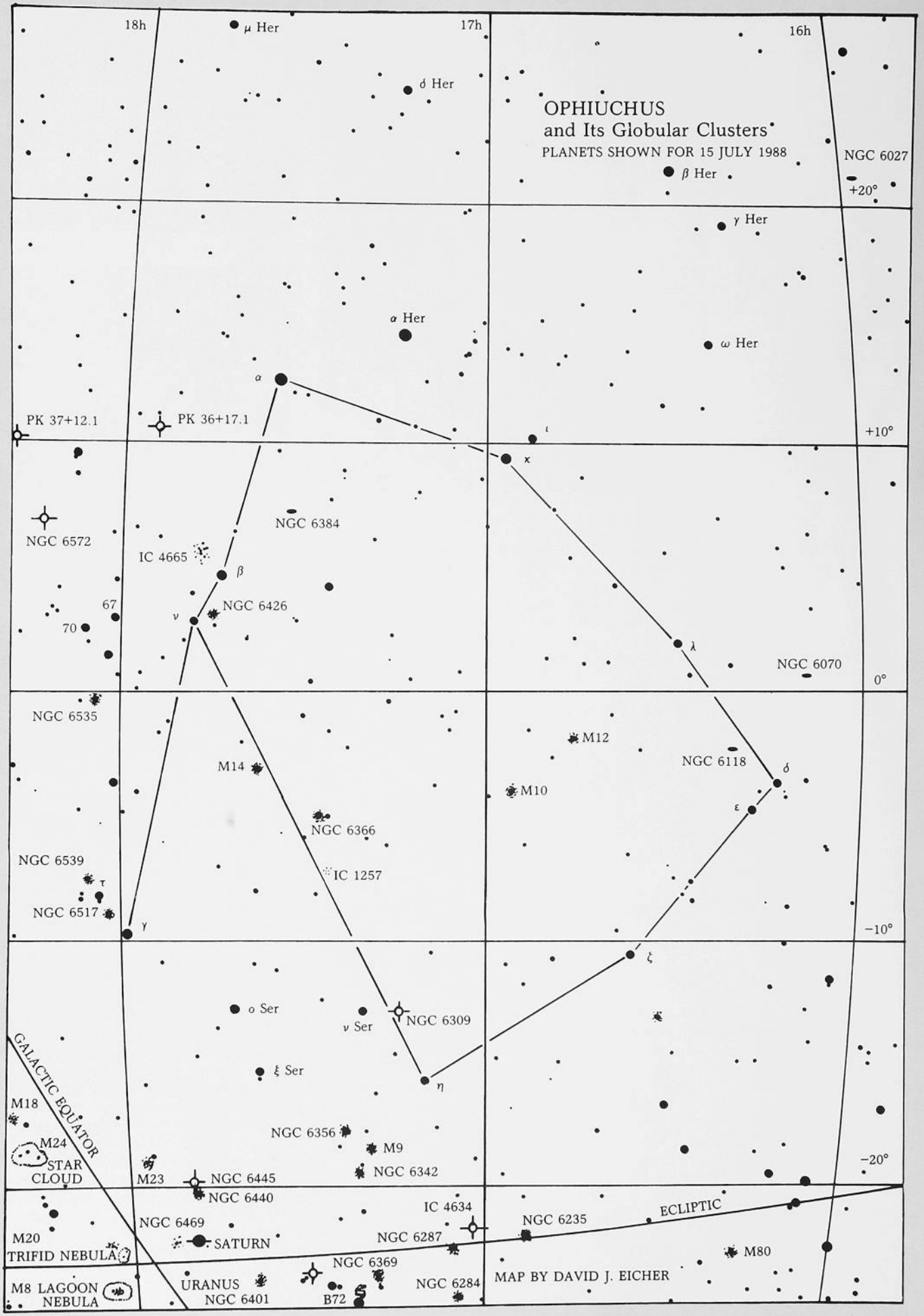
The area around Theta Ophiuchi as a treasure house of deep-sky wonders. Standing out prominently is globular cluster **M19**. Charles Messier discovered this along with M9, M10, M12, and M14 during the spring of 1764. Like the others, M19 is a fine sight in backyard telescopes. Stars are easily resolved across M19 even with low power. One of the first things you will probably notice about M19 is how elongated it seems. The position angle runs nearly due north-south and is distinct enough to be seen in high-power binoculars.

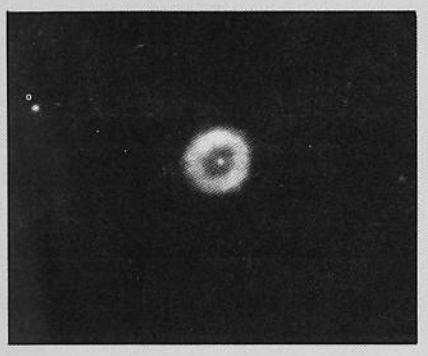
Eight more globulars lie within the vicinity. Of these, **NGC 6293** is the most interesting. At 8th magnitude, it stands out prominently in small telescopes. A large aperture is required to see any individual stars, as the brightest shine at about 14th magnitude.

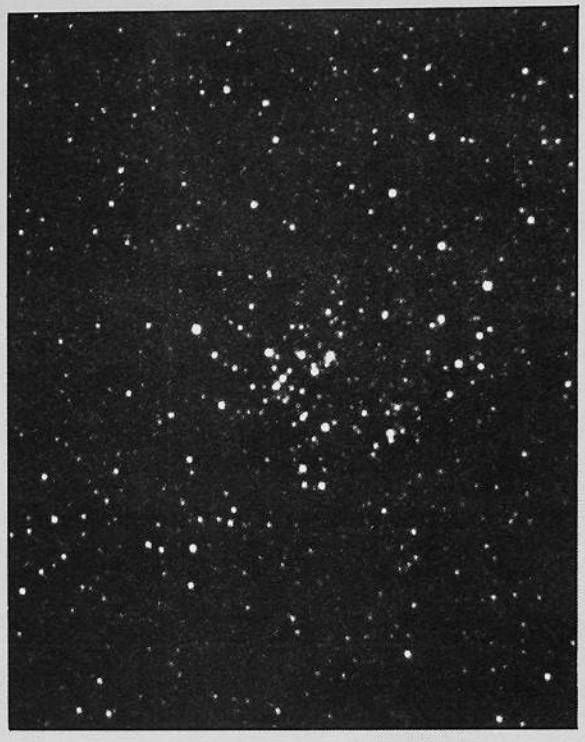
To the southeast lie **NGC 6304** and **NGC 6316**. The former appears as a 9th-magnitude nebulous glow measuring about 3' across. NGC 6316 is a small, densely packed 10th-magnitude globular. Although cluster members may defy detection, a lone magnitude 11.5 foreground star lies superimposed on the cluster's southern edge.

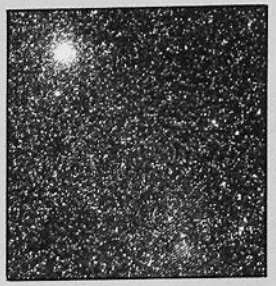
While in the area, take a break from globular hunting and pause to view open cluster **Trumpler 26**. Fifteen stars set within 10' compose this 9th-magnitude swarm. Trumpler 26 is pretty easy to find, because it resides just north of a pair of 4th-magnitude stars.

The remaining globulars in this region are relatively small and faint. They


OPHIUCHUS
and Its Globular Clusters
PLANETS SHOWN FOR 15 JULY 1988
18h
17h
16h
μ Her
δ Her
β Her
γ Her
α Her
ω Her
ι
κ
λ
ν
ο Ser
ν Ser
ξ Ser
η
ζ
NGC 6027
+20°
+10°
0°
−10°
−20°
PK 37+12.1
PK 36+17.1
NGC 6572
NGC 6384
IC 4665
NGC 6426
67
70
NGC 6070
NGC 6535
M14
NGC 6366
NGC 6539
IC 1257
NGC 6517
M12
NGC 6118
M10
NGC 6309
M18
M24
STAR CLOUD
M23
NGC 6445
NGC 6440
NGC 6356
M9
NGC 6342
GALACTIC EQUATOR
NGC 6469
IC 4634
NGC 6235
ECLIPTIC
M20
TRIFID NEBULA
SATURN
NGC 6287
M80
NGC 6369
M8 LAGOON NEBULA
URANUS
NGC 6401
B72
NGC 6284
MAP BY DAVID J. EICHER







Clockwise from above: Globular NGC 6712 and planetary IC 1295 are separated by 20′. Photo by Martin C. Germano. Just 1.5° away from M11 is another impressive cluster, NGC 6704. Photo by Martin C. Germano. NGC 6369 in Ophiuchus is a grand "ring nebula." Photo by Jack Marling. NGC 6309, an odd-shaped planetary in Ophiuchus, is visible in small telescopes. Photo by Martin C. Germano.

include **NGC 6235**, **NGC 6284**, **NGC 6287**, **NGC 6355**, and **NGC 6401** and range in brightness from magnitudes 9 to 11. Only the largest backyard telescopes will show individual stars in any of these clusters and then only with high power.

About 2° southeast of Theta is a huge dark nebula called the **Pipe Nebula**. Best seen with the naked eye, this cloud extends over 7°. In his famous catalogue of dark nebulae E. E. Barnard assigned this formation five separate entries. The bowl is B78, and the pipe's stalk is B59, B65, B66, and B67. On a very dark night the Pipe Nebula stands out well against rich Milky Way star clouds.

A smaller dark cloud lies about 1.5° northeast of Theta. **B72**, known as the "S Nebula," extends about half a degree in length and is most easily seen with very low power. Look for a "hole" in the stars. Dark nebulae are among the most challenging objects for visual observers and among the most rewarding for photographers.

Want a real challenge? Try your luck with **IC 4603** and **IC 4604**, surrounding Rho Ophiuchi. Photographically this is a stunning region of colorful wisps of interstellar clouds north of Antares. Visually these are extremely difficult to detect. But perhaps by using a nebular filter under the darkest skies you just might be possible to catch a glimpse. *Deep Sky* welcomes reports of any sightings of these objects.

Our tour of Ophiuchus closes with a pair of planetary nebulae. **IC 4634** may be found about 6° northwest of Theta Ophiuchi. This is a small but bright object that is detectable in a 6-inch scope if one knows exactly where to look. Its 17th-magnitude central star is too dim to be picked out visually in amateur scopes. **NGC 6369**, at 11th magnitude, should prove to be an easier catch. Robert Burnham describes it as a "perfect ring" in his *Celestial Handbook*. Moderate-size instruments are capable of revealing only a round, featureless glow, but telescopes will show its ringlike character if the object is viewed with averted vision. The 16th-magnitude central star is a tough test for the largest amateur telescopes.

Western Serpens, known formally as Serpens Caput or the Serpent's Head, plays host to eight bright galaxies but is best known as the home of **M5**. Discovered 285 years ago by Gottfried Kirch, M5 is one the sky's great deep-sky objects.

Over half a million stars combine to create this 6th-magnitude globular cluster. Visible as a fuzzy "star" with the naked eye on clear nights, a high-quality 3-inch telescope will begin to resolve the group. My 8-inch telescope reveals countless stars scattered across its disk with several bright knots visible along the southern and eastern edges. The apparent size of M5 grows to half a degree in large scopes. Perhaps because of its location away from bright naked-eye stars, M5 is frequently ignored at summer star parties in favor of M13 in Hercules. This is a shame. Be sure to to marvel at the beauty of M5 on the next clear night.

Of the eight galaxies scattered through Serpens Caput, **NGC 5962** appears to be the brightest at magnitude 11.5. (NGC 5921 is brighter but has a lower surface brightness.) Its 2′-diameter disk appears slightly oval and is easy to spot even through less than ideal sky conditions. **NGC 5921** lies about 3° north of M5 and may be spotted as a 4′ by 3′ patch of 11th-magnitude light. Large scopes may be able to distinguish a slightly brighter nucleus. About a magnitude fainter is **NGC 6070**. Its long disk is highlighted by a bright central nucleus that is visible in a 6-inch telescope.

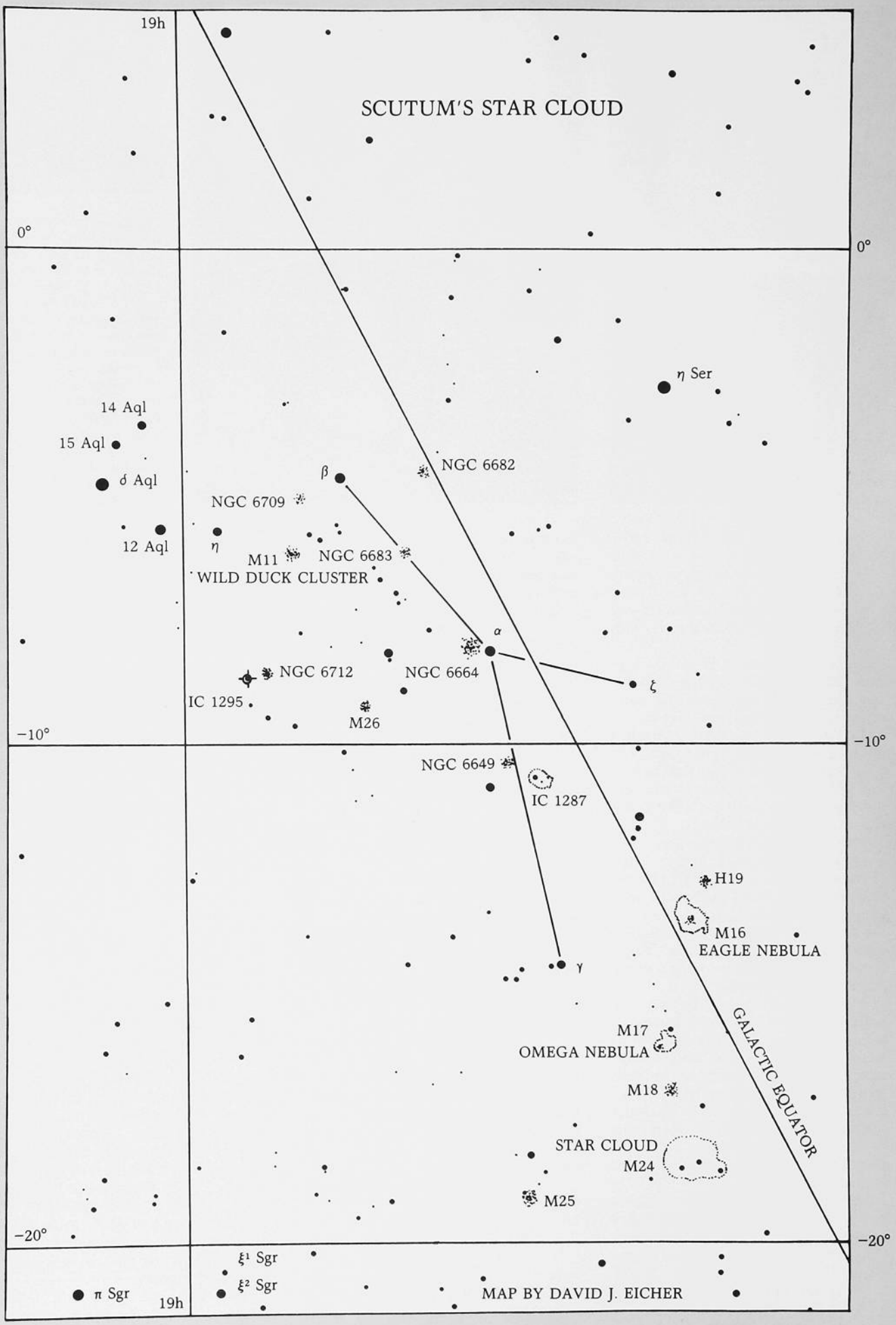
Near the Serpens/Ophiuchus border is **NGC 6118**, a faint, oval spiral galaxy. This one is located near a 6th-magnitude field star, which slipped by unplotted on the *Sky Atlas 2000.0*.

Next try your luck with **NGC 5970**. This galaxy's magnitude is 11.4, although some catalogues list variant magnitudes. Nearby is **NGC 5936**. This is a round, magnitude 12.4 galaxy that is difficult to spot in small telescopes. It lies just east of 7th-magnitude star, which tends to overpower the galaxy's subtle light. **NGC 5984** is the most difficult of all these spiral galaxies. Its 12th-magnitude glimmer will appear noticeably cigar-shaped, if it is visible at all.

Be sure to pause at **NGC 6027**. Though it bears only a single entry in Dreyer's *New General Catalogue*, NGC 6027 is in reality a group of five S0 and elliptical galaxies that seem physically attached to one another by luminous bridges of material. The similarity to Stephan's Quintet in Pegasus is striking. The galactic members range from 14th to 15th magnitude and so require at least a 10-inch telescope to be seen.

The galactic plane of the Milky Way passes through eastern Serpens, known as Serpens Cauda, the Serpent's Tail, but this region is surprisingly poor in nonstellar objects.

NGC 6535 is a small, faint globular cluster situated just west of a 6th-


SCUTUM'S STAR CLOUD
19h
0°
0°
η Ser
14 Aql
15 Aql
δ Aql
12 Aql
β
NGC 6682
NGC 6709
η
M11
NGC 6683
WILD DUCK CLUSTER
α
NGC 6712
NGC 6664
ζ
IC 1295
M26
−10°
−10°
NGC 6649
IC 1287
H19
M16
EAGLE NEBULA
γ
M17
OMEGA NEBULA
M18
STAR CLOUD
M24
M25
GALACTIC EQUATOR
−20°
−20°
ξ¹ Sgr
ξ² Sgr
π Sgr
19h
MAP BY DAVID J. EICHER

magnitude star. Large amateur telescopes might be able to show a few distinct stars, but they are difficult. At magnitude 10.5 and only 1′ across, NGC 6535 will bear magnification well.

The most spectacular object at either end of the serpent is the emission nebula and cluster **M16**. Its discovery is credited to Swiss astronomer Pierre de Cheseaux in 1746. Eighteen years later Messier noted that the cluster stars appeared "enmeshed in faint light." This is the earliest reference mentioning nebulosity associated with the cluster. Actually, M16 is surrounded by faint billowing clouds that extend nearly half a degree.

M16's star cluster appears as a loose scattering of about sixty stars across a 25′ area, offering a fine sight in binoculars and small telescopes. Until recently the nebula, known popularly as the Eagle Nebula, was mistakenly considered a difficult visual challenge. But thanks to dark skies and nebular filters, the Eagle has now been viewed by thousands of people.

Using my 4.25-inch RFT, I was able to spot the distinctive object through a 26mm Plossl/Daystar nebular filter combination. With the same pairing placed in my 8-inch scope, the striking contrasts between bright and dark clouds are a wonder to behold. Fred Hoyle's "Elephant Trunk" dark nebula formation was distinct. Hoyle contends that the bright nebulosity is rapidly expanding into cooler gases and swelling outward as a result.

Though only 3° northwest of M16, **Trumpler 32** tends to be ignored by most observers. Look for a small collection of faint stars within a 5′ area. Backyard telescopes do not give an especially impressive sight of Trumpler 32. Its dim glow may be easily passed over in a casual search.

The brightest stars of Scutum are only 3rd magnitude and easily lost in the Scutum star cloud. This region is among the most beautiful to scan with binoculars. Innumerable stars are sprinkled here with a richness that is surpassed by few other places in the sky. Barnard referred to the Scutum star cloud as "the gem of the Milky Way," a title fitting this magnificent part of the summer sky.

Lying between us and the northern boundary of the star cloud is **M11**, an unusually condensed open cluster that is always a crowd pleaser at club observing sessions. Discoverer Gottfried Kirch noted in 1681 that it seemed like a "small, obscure spot with a star shining through." Small telescopes can easily duplicate Kirch's impression at low power, which causes M11 to look like an unresolved globular cluster. As telescope size increases, M11 becomes a clump of myriad jewel-like stars. Most range from magnitude 11 to 14 with a lone 8th-magnitude maverick shining prominently.

Many past astronomers, among them William Herschel, have noted that M11 seems to consist of several stellar aggregations, each distinctly separated from the others. Admiral Smyth was impressed by the main stellar grouping's resemblance to a "flight of wild ducks" and is credited with giving this group its nickname, the "Wild Duck" cluster. Do you see these same patterns?

Three patches of dark nebulosity surround M11 and present a difficult challenge to visual observers. **B108** is a 3′-diameter cloud located only 25′ west of the cluster. Use medium power for the best view. **B318** is considerably more difficult. It stretches over 1° in length but is only a few arcminutes wide. Walter Scott Houston reports seeing it in the 12-inch f/17 Porter Turret telescope at Stellafane in Springfield, Vermont, and suggests that large backyard instruments should pick it out easily.

Next we come to **B112**. Located about 30′ southeast of M11, this is an ill-defined cloud partially masked by several stars scattered across it. Barnard discovered most of his catalogue entries photographically, where they appear far more obvious than they do visually.

About a degree north of M11 is open cluster **NGC 6704**. I can still remember a night about a dozen or more years ago when I got a frantic call from a friend who had recently purchased his small, first telescope. He excitedly told me how he had just discovered a 10th-magnitude comet north of M11. A little investigation revealed that he had actually seen NGC 6704, but to this day we call it "Ken's Comet." NGC 6704 is actually a rich open cluster. Twenty-five faint stars lie within its 2′ border. Small wonder that my friend was unable to tell it apart from a newborn comet, because at least a 6-inch scope is required for resolution. How many readers can admit to having accidentally "discovered" Ken's Comet?

About 2.5° south of M11 lies **NGC 6712**. This is the only distant globular cluster in Scutum that can be seen through the many obscuring clouds and stars along the plane of our Galaxy. Its glows at 8th magnitude, and the object measures about 3′ across. Because the cluster is Class IX, a 10-inch scope begins to resolve some of the individual 14th-magnitude stars. The many surrounding field stars frame the cluster nicely.

Less than half a degree to the east is planetary nebula **IC 1298**. Many catalogues underestimate the brightness of its 80″ by 60″ disk, listing it at 13th or 14th magnitude. However, I found it to be easy in my 8-inch scope at low power. A nebular filter may help its visibility slightly. When searching, use a wide-field eyepiece. First center on NGC 6712, and then shift the globular over toward the western edge of the field. Doing so should place IC 1295 somewhere near the center of the field. The central star at 15th magnitude will probably prove difficult to spot in backyard scopes.

Just south of Beta Scuti is one of the nicest variable stars visible through modest equipment. **R Scuti** fluctuates in brightness from magnitude 4.9 to 8.2 over a 140-day period. Typically R Scuti ranges between magnitude 5 and 6 but dips to 8th magnitude every fourth or fifth cycle. Though it's identified as an RV Tauri star, characteristics of both Cepheids and long period variables have been detected. These combine to make R Scuti a truly remarkable star, over 80 million miles in diameter. R Scuti's layers are continually expanding and contracting at different rates, which cause its varying appearance.

Bordering Alpha Scuti to the east is **NGC 6644**. This is a coarse collection of dim stars scattered across 15′. Many observers have commented on the richness of the group; Kenneth Glyn Jones called attention to its U-shaped appearance in the Webb Society's *Deep Sky Observers's Handbook*, Volume 3.

NGC 6682 and **NGC 6683** are two large collections of many faint stars. Although originally thought to be open clusters, these are generally accepted as just a pair of rich star clouds. Still, each presents a pleasing sight through a wide-angle eyepiece.

Located about a third of the way between Alpha and Gamma Scuti is **NGC 6649**, another rich open cluster. Most of its stars are magnitude 10 and fainter, with a single 9th-magnitude orb lying southeast of its center. A 4-inch shows only a nebulous glow with a few stars sprinkles about, while a 6- to 8-inch telescope dissipates the cloudy effect to reveal many points of light. Just to the southeast is **IC 1287**. Look for a faint patch of nebulosity surrounding the binary **ADS 11414**, a wide pair of 6th- and 9th-magnitude stars (p.a. 257°, sep. 12.4″). Wait for a crystal clear night for the best chance of seeing this object.

M26 is the second Messier object in Scutum. Discovered nearly 340 years ago by LeGentil, M26 is not as striking as some of its neighboring members of the NGC. Most instruments reveal four stars set in a diamond pattern with a splattering of dimmer stars surrounding them. M26 is about 1.6 kiloparsecs away, about 170 parsecs closer than M11.

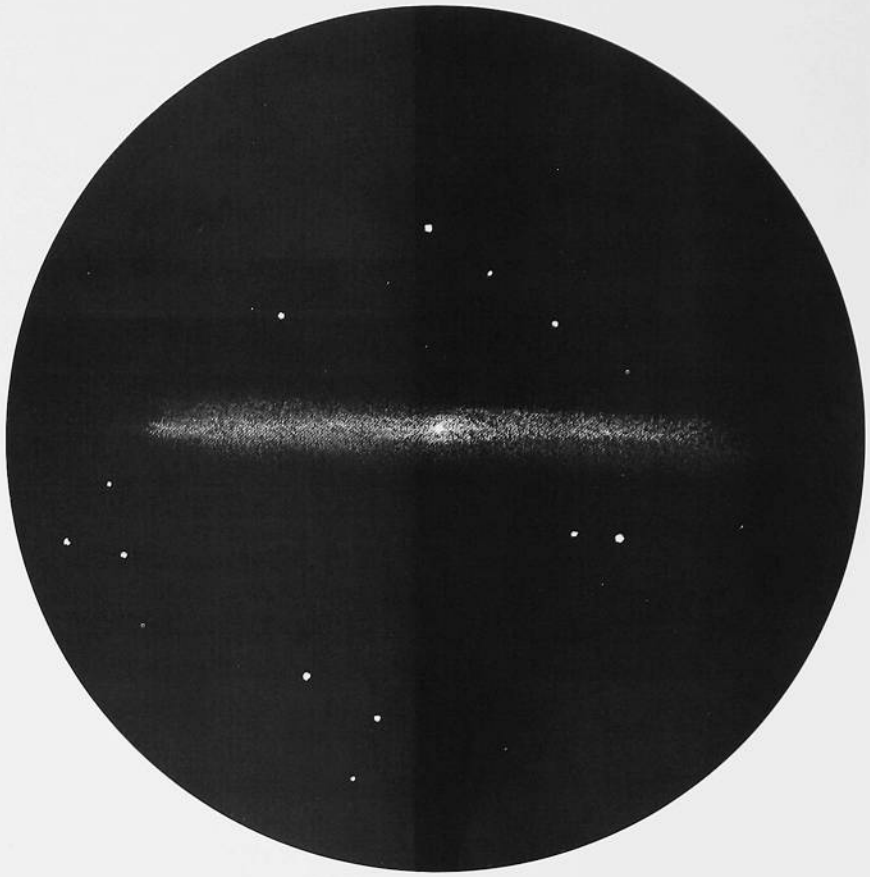
Ophiuchus, Serpens, and Scutum bridge the gap between the galaxy-filled spring sky and the magnificent summer Milky Way. With these constellations placed at their best, now is the perfect opportunity to discover the many pleasures they contain.

DSM Reports

Exploring Galaxies in Hydra

Some time ago a group of enthusiastic amateur astronomers from Arizona and Australia sent me a batch of excellent sketches. The sketches depicted various deep-sky objects, mostly galaxies, in the often overlooked constellation Hydra. Because of the excellence of these sketches, I would like to share some of them with you. Technical information for each drawing appears at the appropriate place.

— David J. Eicher

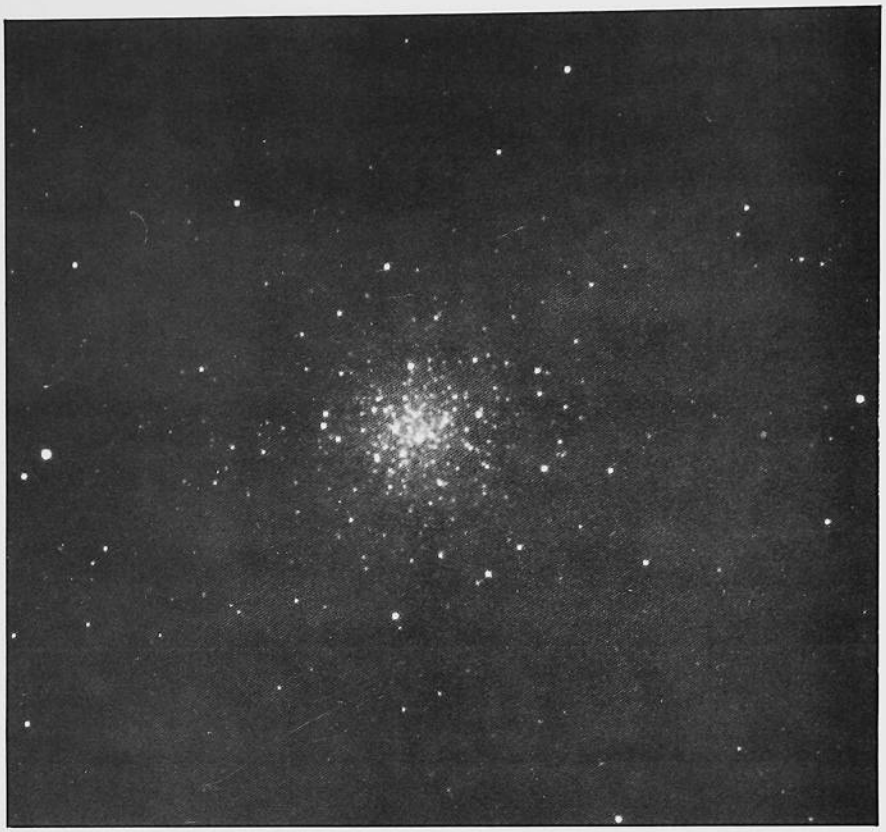


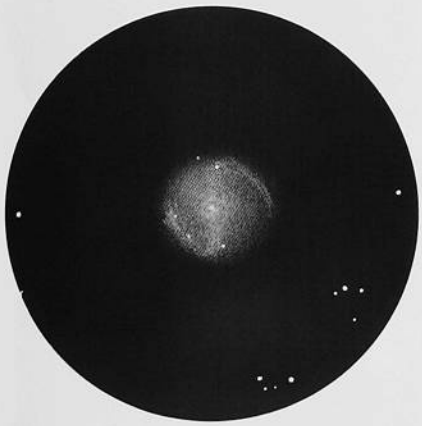
NGC 3109
Steve Coe
17.5-inch f/4.5 telescope
100x

The low surface brightness galaxy NGC 3109 photographed with the 61-inch astrometric telescope at the U.S. Naval Observatory in Flagstaff, Arizona. This is a 160-minute exposure on IIa-O film made on February 11, 1969. Official U.S. Navy photograph.

M68
A. J. Crayon
8-inch f/6 Newtonian
100x

M68 photographed with an 8-inch f/10 SCT, hypersensitized Tech Pan film, and a 25-minute exposure. Photo by Jack Metcalfe.





M83
A. J. Crayon
8-inch f/6 Newtonian
120x

M83 photographed with an 8-inch f/10 SCT, 103a-F film, and a 50-minute exposure. Photo by Martin C. Germano.

NGC 2610
Steve Coe
17.5-inch f/4.5 reflector
165x

NGC 2713 and NGC 2716
Steve Coe
17.5-inch f/4.5 reflector
100x

NGC 2784
Steve Coe
17.5-inch f/4.5 reflector
100x

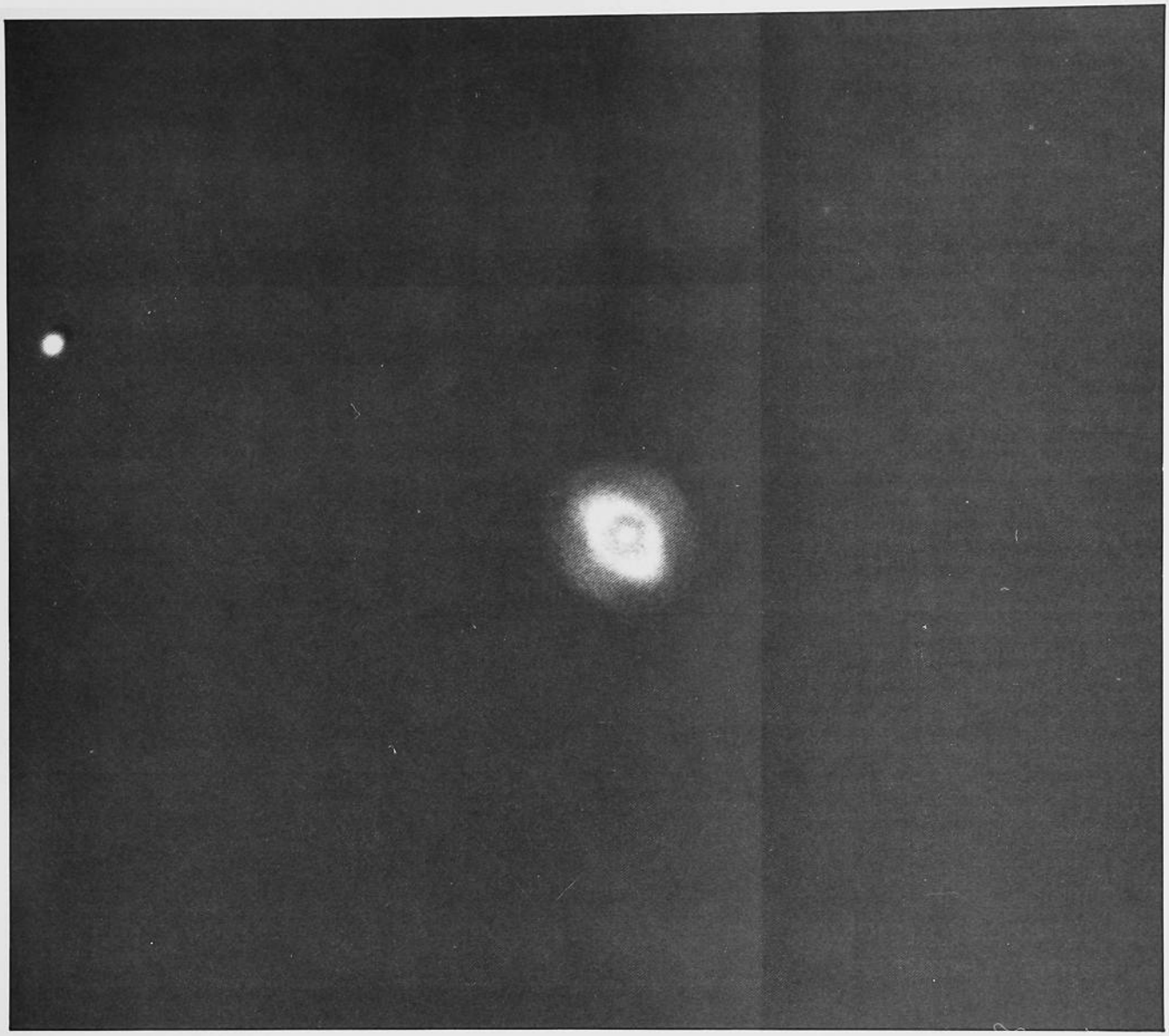
NGC 3145 and Lambda Hydrae
Chris Schur
16-inch f/5 reflector
144x

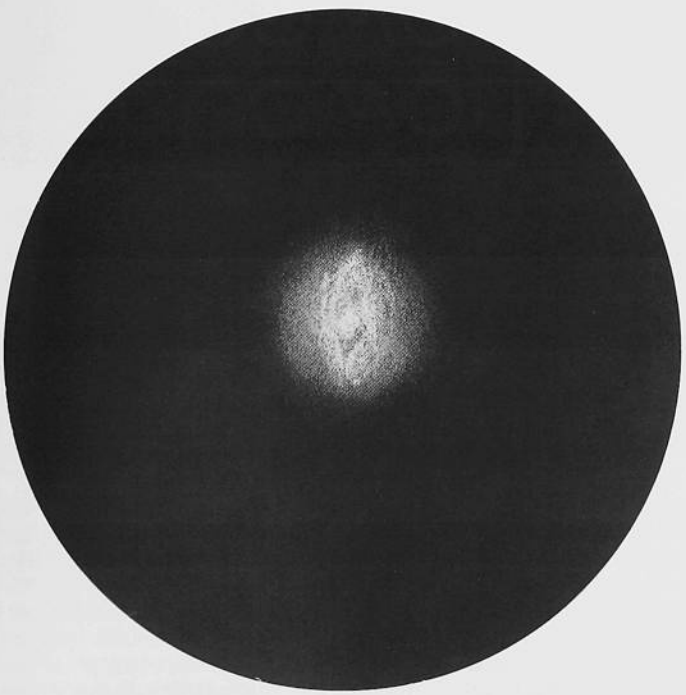
Hydra Galaxy Cluster
NGC 3309, NGC 3311, NGC 3312,
and NGC 3316
A. J. Crayon
8-inch f/6 Newtonian
100x

NGC 3621
A. J. Crayon
8-inch f/6 Newtonian
80x

NGC 5061
A.J. Crayon
8-inch f/6 Newtonian
100x

NGC 5694
A. J. Crayon
8-inch f/6 Newtonian
175x





NGC 3242, the "Ghost of Jupiter," photographed with a 24-inch f/5.6 Cassegrain telescope from Mauna Kea, Hawaii. The exposure was 10 minutes on Fujichrome 400 negative film. Photo by Jack B. Marling.

NGC 3242
A. J. Crayon
14.25-inch f/5.5 telescope
400x

Stock 2: Living in the Shadow of the Double Cluster

by Alister Ling
and Jonathan Doupe

Lying on a deck chair with binoculars in hand, you watch bright meteors flash across the sky. Drinking in the magnificence of the Milky Way, you're oblivious to the world. As your eyes wander along the Galaxy you spot a lifelong friend, the Double Cluster in Perseus. With a pair of binoculars you leave Earth and travel out to your friend. This time, however, your heightened senses reveal a small cluster a couple of degrees north of h and χ.

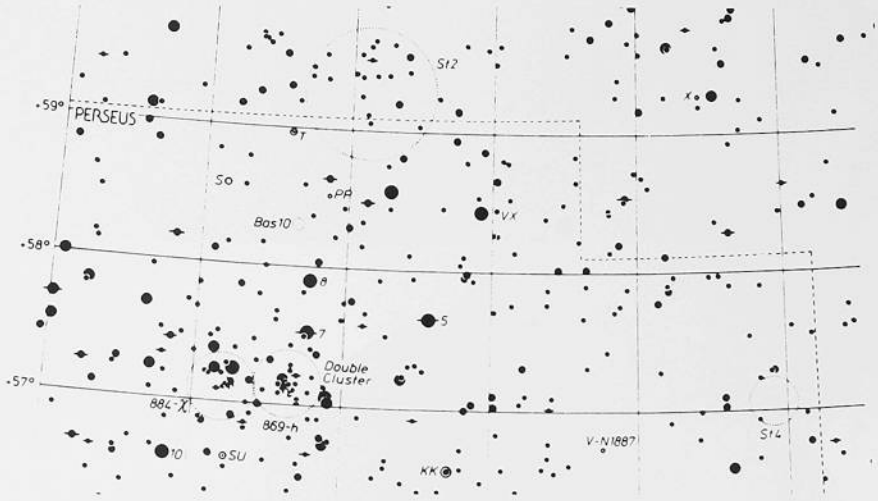
Slightly smaller than the Double Cluster, Stock 2 appears in 7x50 binoculars as an extensive group of faint stars. Most of its fifty or so stars are 9th magnitude or fainter; a few shine at about 8th magnitude. This group has an integrated magnitude of 4.4, so you might expect to see it with the naked eye, but its large angular size (1°) results in low surface brightness.

Stock 2 is approximately seven times closer to us than the Double Cluster is, which makes it much smaller than either of the Double Cluster components. Stock 2 spans about 5.6 parsecs, whereas each of the Double Cluster members measure approximately 20 parsecs across. Stock 2 must have been born in a fairly thin, homogeneous gas cloud, because none if its members is intrinsically bright like several in the Double Cluster. At the age of 100 million years, Stock 2 is a mature open cluster but far from one of the oldest. The Double Cluster components, on the other hand, are 5.6 million and 3.2 million years old (NGC 869 and NGC 884, respectively).

In 7x50 binoculars the authors can resolve fifteen stars in Stock 2. The separation of the cluster from the starry background becomes obvious with averted vision. With increased aperture the cluster's shape changes from round to elongated in a north-south direction as fainter stars north of the cluster's center become visible. The cluster's large angular diameter makes it appear like a region of great star density rather than a nebulous patch of light. Stock 2's stars have a much narrower range of brightness than those in the Double Cluster.

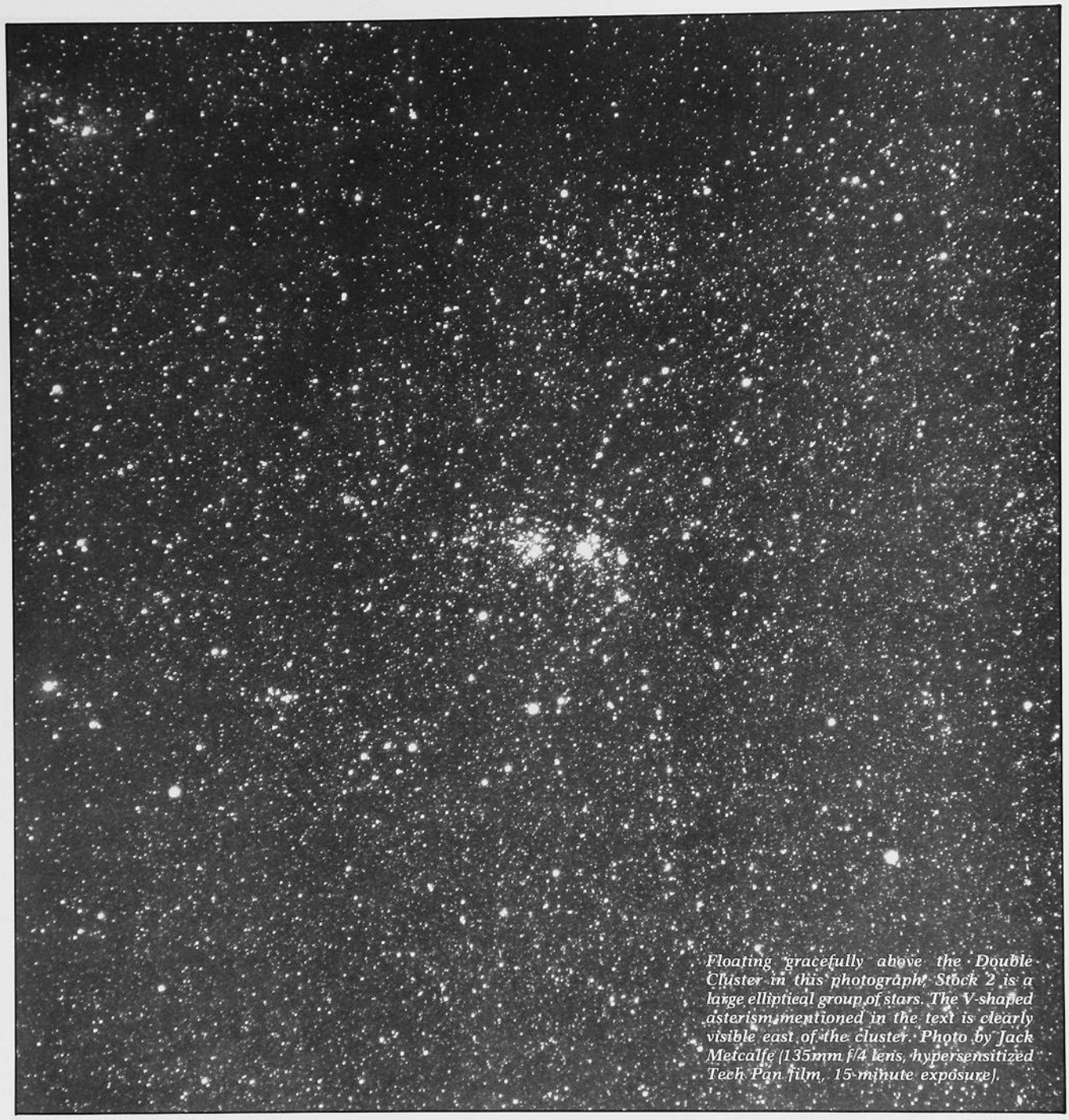
In a 2.5-inch telescope at 14x the light-polluted sky in Toronto restricts the view of Stock 2 to a granular patch of a few stars, but a dark sky provides a pleasing view. Large binoculars or small RFTs are probably the best instruments for viewing this cluster. A V-shape formed by 7.5-magnitude stars just east of Stock 2 suggests a bug with antennae or a pineapple. The beautiful wide pair OΣΣ 26, just northeast of the cluster, shouldn't be missed in such instruments. Its magnitude 6.9 and 7.4 components are separated by 63", which makes the pair easily visible in most instruments.

In larger telescopes Stock 2 becomes increasingly difficult to view. An 8-inch telescope shows many faint stars within the group and also reveals a dark "ring" of rather empty space around the cluster. This makes the group appear detached from the background Milky Way, especially to the north. A 12.5-inch telescope provides this same effect, but only half of the cluster can be viewed at once. The dark ring is not visible on the Palomar *Sky Survey* prints



Top: Stock 2 appears as a large, scattered group of faint stars in this drawing with north up and west to the right. Paul Brown of Goderich, Ontario, used an 8-inch f/7 reflector at 45x for the sketch.

Above: The field containing the Double Cluster, Stock 2, and Basel 10 is a rich section of Perseus and Cassiopeia. This reproduction is a section from chart 37 of* Uranometria *2000.0, copyright 1987 Wilmann-Bell, Inc.



Floating gracefully above the Double Cluster in this photograph, Stock 2 is a large elliptical group of stars. The V-shaped asterism mentioned in the text is clearly visible east of the cluster. Photo by Jack Metcalfe (135mm f/4 lens, hypersensitized Tech Pan film, 15-minute exposure).

The Double Cluster Field

Object	R.A. (2000) Dec.	Con.	Mag.	Mag.★	Size	Distance	Diameter
Stock 2	2h15.0m +59°16′	Cas	4.4	8.2	60′	320 pc	5.6 pc
Basel 10	2h18.8m +58°19′	Per	9.9	10.2	—	2600 pc	—
NGC 869	2h19.0m +57°09′	Per	4.3p	6.6	30′	2200 pc	19 pc
NGC 884	2h22.4m +57°07′	Per	4.4p	8.1	30′	2300 pc	20 pc

because of the many faint stars that fill in the gaps.

Lying almost halfway between Stock 2 and the Double Cluster is a small group of stars designated Basel 10. In a 12.5-inch telescope this cluster consists of two lines of stars, totaling fifteen in all. Two of the stars are brighter than the rest. There is a small clump of four or five stars embedded in the northern line. With a total magnitude of 10, Basel 10 is visible in an 8-inch telescope as a tiny sprinkling of stars.

Stock 2's shape has always seemed fascinating. You may observe the cluster and find that it doesn't resemble a pineapple but something completely different. When you're out under the stars this summer, be sure to check this area and record your impressions for the future.

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Small Scope Showcase

Messing Around in the Messier Catalogue

by David H. Levy

The Messier catalogue. No one can be involved with backyard astronomy for more than about two weeks without hearing about this famed list of classic deep-sky objects. Many astronomy clubs have even sprouted "Messier clubs"; their objective is to view everything on the canonical list, and countless more individuals have chased down each object on their own.

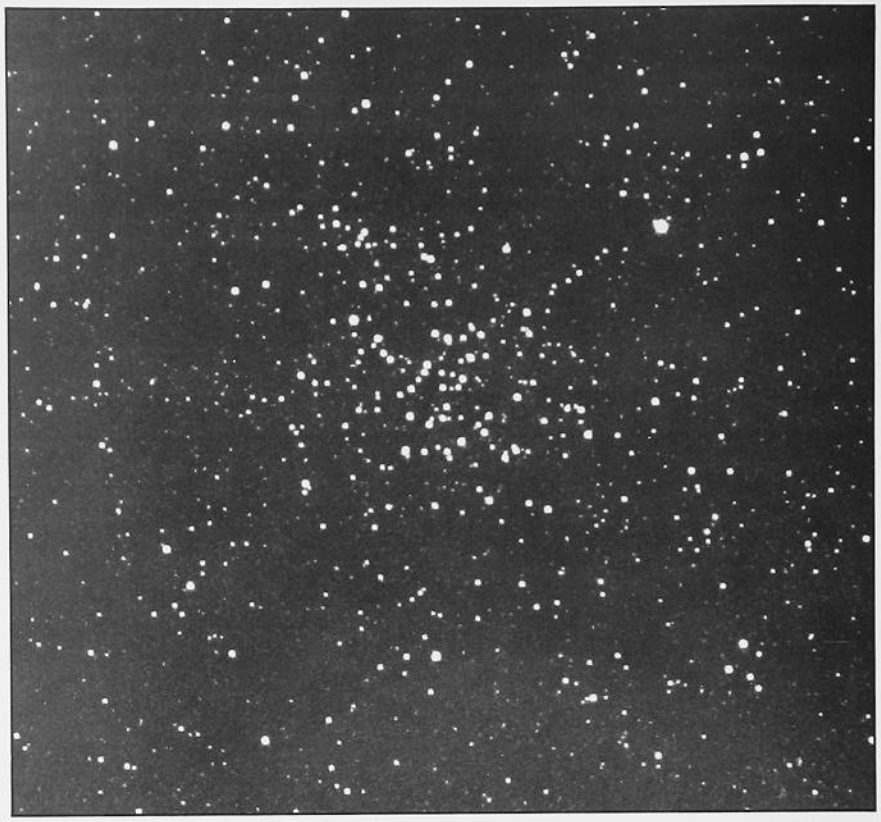
Who was Messier? Born in 1730, Charles Messier was a French astronomer who became the world's first systematic comet hunter. He began his work in earnest after he failed to be the first to recover Halley's Comet on its 1758 return. During the years of methodical searching that followed, he found at least a dozen comets (he shared some discoveries with other comet hunters). In the process, however, he also found many objects that resembled comets but lacked hourly or daily motion, which gave them away as objects of the deep sky.

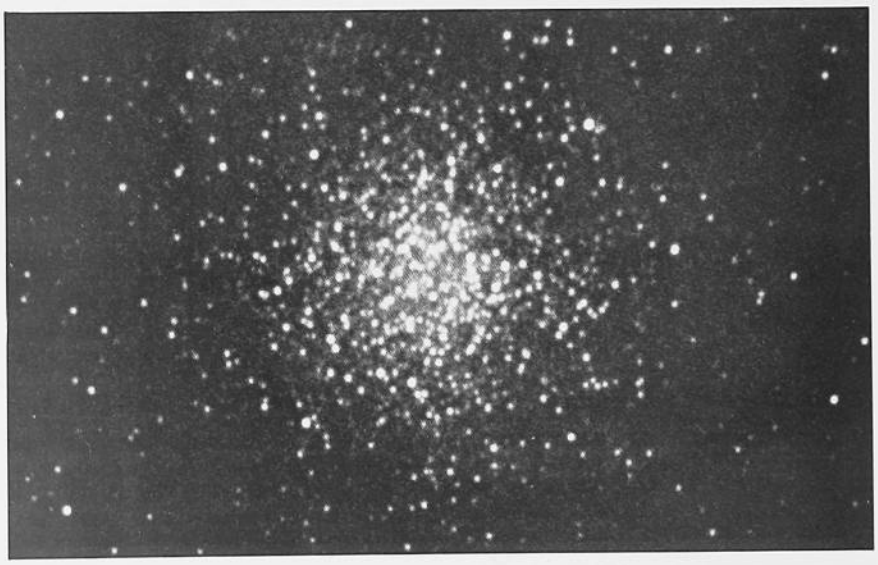
Today hardly anyone remembers Messier for his comets, most of which have long since departed from the inner solar system for the distant edges of the Sun's realm. Messier's fame nowadays lies in the catalogue of objects he wished to avoid! Observing the entire collection of 107 galaxies, clusters, and nebulae is a worthwhile goal for any telescope owner.

Many observers enjoy the competitive spice that joining a Messier club provides. You can find a Messier club in nearly every astronomical society in the land, but the first of them may well have been the one founded in Montreal, Quebec. Started in the 1940s by Isabel Williamson, its aims were simple: "Telescope required. A friendly competition to locate and identify all the objects in Messier's catalogue. Honour system."

A notice board at the observatory of the Montreal Centre of the Royal Astronomical Society of Canada carried a list of observers with a darkened square for each Messier object "bagged." Those completing the list were encouraged to move on to the Herschel club, which consisted of many hundreds of (usually) more difficult objects originally found by William Herschel.

I began observing the Messier objects in August 1962 and finished in May





Top: M23 in Sagittarius is a bright, scattered cluster of 150 stars visible in binoculars. Photo by Rick Dilsizian, 8-inch f/1.5 Schmidt camera, hypered Tech Pan film, 3-minute exposure.

Above: One of the largest and loosest globular star clusters, M55 in Sagittarius is visible in binoculars and small scopes as a mottled haze. Photo by Martin C. Germano, 8-inch f/10 SCT, 103a-F film, 50-minute exposure.

Opposite page: M16, known variously as the Eagle or Star-Queen Nebula, is a large complex of stars, emission nebulosity, and dust. Under perfect conditions a 6-inch telescope may show obscuring patches against the bright nebulosity. Photo by Kim Zussman, 11-inch f/10 SCT, hypered Tech Pan film, 70-minute exposure.

1967. Four reasons lead me to recommend this project to you, even if you're not a member of any club and sky watch on your own. First of all, "doing the Messiers" will introduce you to all the various kinds of deep-sky objects you can see with your telescope. It includes elliptical, spiral, and irregular galaxies; open and globular clusters; planetary and emission nebulae; and a few odd stars and misidentifications that probably don't belong at all.

Second, if you ignore your equatorial mounting (if you have one) and simply star hop your way to the objects with your finder scope, viewing the list will make you thoroughly at home with the sky and its constellations. Third the experience will get you using your telescope like a champ and teach you much about its performance. The fourth and last reason is the most important — it's fun!

A few years ago some misguided person decided to take the Messier club idea one step farther and created the "Messier marathon." Finding these objects during your lifetime wasn't enough; now you gotta see 'em all in one night! (As I recall, viewing on a Moonless night in spring was the key.) Like all things trendy, Messier marathons have (thankfully) gone out of fashion. The one good thing in such an *observatio ad absurdum* is that you can compare M42 in Orion with M8 in Sagittarius on the same night when your memory is fresh.

Most Messier objects are easy to find — *Sky Atlas 2000.0* is ideal to use — and few pose any real viewing challenges. (Messier's largest telescope was a 7-inch instrument and he often used smaller ones.) Open clusters, for example, are usually widely spaced and easily resolved groups of stars — the famous **Pleiades** (M45) are an extreme example. Usually viewed in winter, the Pleiades are visible on a summer night if you stay up late enough and catch them rising in the northeast as dawn begins.

Visible most of the night is a fantastic open cluster in Scutum, the **Wild Duck Cluster** (M11), so-called because of its overall appearance at medium power. Consisting of a marvelous swarm of blue stars with a bright orange star in the center, M11 is a real treat. Two clusters in Scorpius lie in the same general region, **M6** and **M7**. These can be seen clearly in binoculars or a finder scope, but only your main scope will reveal their individual stars. **M18** is also visible just south of **M17**, although it's more difficult than M6 or M7. **M21**, **M23**, and **M25** are quite prominent in Sagittarius. Farther north up the Milky Way, Cygnus offers two open clusters: the triangular **M39** and the more difficult **M29**, which is hard to appreciate fully in a small scope (though you can locate it).

Globular clusters are fuzzy blobs containing thousands and thousands of stars, some of which can be resolved in telescopes bigger than about 8 inches. **M13** in Hercules is the most famous of the summer globulars, but in Sagittarius **M22** is one of the nicest in the entire sky and would rival M13 if it rose higher. (I'm deliberately ignoring far-southern gems such as Omega Centauri, because they aren't visible for most North American observers.)

Globulars swarm around the center of the Galaxy, so the Sagittarius region is thick with them. In addition to M22, try **M28, M54, M55, M69, M70**, and **M75**. Other summer globulars include **M56** in Lyra, **M92** in Hercules, and a large collection in Ophiuchus that includes **M9, M10, M12, M14, M19, M62**, and **M107**. Scorpius has two easy Messier globulars; one is **M4**. This cluster is relatively unconcentrated and presents a different appearance depending on what telescope size and focal length you use. The other globular in Scorpius, **M80**, is much smaller and more concentrated.

Shining by emitted or reflected light, gaseous nebulae are especially inviting under dark-sky conditions. (In fact, many observers use their visibility as a gauge of a night's quality.) The summer Messiers include M8 and M20, the **Lagoon** and **Trifid nebulae**, respectively. These are two of Sagittarius' most impressive sights along with the **Omega Nebula** (M17). (Its delicacy makes it my personal favorite.) A little north in Serpens you can find M16, the **Eagle Nebula**.

Planetary nebulae are spheres of gas that have been expelled from certain kinds of stars as they age. They are usually round and their blue-green or gray-green disks sort of resemble the planets Uranus and Neptune (hence the name). Planetaries are not common in the summer Messier list, but two of the best are there: the **Ring Nebula** (M57) in Lyra and the **Dumbbell Nebula** (M27) in Vulpecula.

Why no galaxies in summer? Well, Ursa Major has fine bright ones in **M101** and **M51**, and if you stay up late, you can catch **M31** in Andromeda. But summer is the time when our own Galaxy, the Milky Way, dominates the sky. Its thick regions of dusty gas — the birthplaces for stars and open clusters — act as a natural filter, which confines the nightly view to our own "local" splendors.

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DSM Reviews

1000+: The Amateur Astronomer's Field Guide to Deep Sky Observing
Tom Lorenzin with Tim Sechler
159 pp., spiral bound, $39.95
1000+ (1987)
[publisher's address: P.O. Box 700-T, Davidson, NC 28036]

After reading about *1000+* in advertisements for a couple of months, I finally got hold of a copy and was delighted to see it. The book is a compilation of information for deep-sky observers by a couple of amateur astronomers living in North Carolina. Its primary attraction is a 1,200-object database (hence the name), but chapters preceding the database dabble in many facets of deep-sky observing.

The book's text is delightfully enthusiastic. A paragraph in chapter one proclaims, "The astronomy lover no longer needs to rely on printed pages, video or projection screens to witness the magnificent (and sometimes subtle) glory of the deep sky. With a little guidance, knowledge, and the right tools *anyone* can become an experienced deep-sky observer with more than 1000 deep sky objects to his or her credit."

With this as the underlying premise, the authors next tackle telescope basics, finding objects in the sky, and useful accessories for deep-sky observing. The chapters generally are short but include plain explanations and photographs that usually contribute to an understanding of what's going on. After these sections the authors discuss more accessories, sky conditions, naked eye astronomy, "indoor astronomy," and sketching.

The book's rambling dialogue allows the authors to highlight specific things they want to discuss. This generally works, though in some cases it doesn't. I was surprised to see that in the naked-eye observing section the authors neglected deep-sky objects and opted for a rudimentary discussion of meteor observing. In the brief section on filters the authors devote five column inches to filters for observing planets. While I have nothing against knowing about planetary filters, including filters in a book about deep-sky observing only serves to defocus the narrative.

A larger-scale problem is that the book doesn't always seem to know who its audience is. After pitching in the beginning that *anyone* can look at deep-sky objects — and I presume that includes people who don't yet have a telescope or any knowledge of galaxies — the book assumes the reader has a fair amount of knowledge.

"Hardball Deep Sky Observing," the authors contend, "requires a basic understanding: The telescope isn't a badge; it's a *tool*." In another section a reference is made to occultation timings with the explanation, "if you think occultation timing is a schedule of seances, contact IOTA. You'll find the address in Appendix A." This probably confuses people who aren't already familiar with amateur astronomy.

The database has a few problems too. Although the authors state in the book that they checked *Sky Catalogue 2000.0*, a reliable source of data, they seem not to have systematically used the information in it. Descriptions for some objects agree with *SkyCat2* while others don't.

Nevertheless, the book isn't intended to be a data table for all of the objects. The charm of the *1000+* list is the excellent selection of objects to view. The list, along with an accompanying series of star charts, provides a superb program of good objects to observe. On this level, and this is the book's real aim, *1000+* is a complete success.

Astronomical Centers of the World
Kevin Krisciunas
320 pp., cloth, no price given
Cambridge University Press,
New York, 1988

This fascinating book looks at the history of astronomy through the great centers of research that have existed over the past two thousand years. Beginning with the great library at Alexandria, the author describes the evolution of astronomical thought and how astronomy has worked through the ages.

The book — and rise of astronomy — really consists of three parts. First comes the early observational astronomy of the Alexandrians and, after the passing of several centuries, a period of growth in astronomy in the Moslem world. Tycho Brahe greatly influenced the astronomy world in the 1500s at his observatory in Hven, Denmark. Others dramatically changed the face of astronomy too, but a radical change came about in the seventeenth century.

The observatories at Paris and Greenwich, founded in the late 1600s, introduced a systematic approach to observational astronomy. They were the powerhouses of their time, along with the Pulkovo Observatory in St. Petersburg. Simon Newcomb's U.S. Naval Observatory in Washington vied for the glory along with these institutions in an era when star cataloguing, solar and lunar astronomy, and positional astronomy reigned supreme.

The author describes the third phase, the explosion of modern astrophysics, in the following section. Harvard, Lick, and Yerkes observatories thrust new ideas and new technology forward to unlock new secrets of the universe. The second phase of this explosion occurred at Mount Wilson and Palomar Mountain observatories in California.

The book concludes with a discussion of present day research centers, most significantly Kitt Peak in Arizona, Mauna Kea in Hawaii, and the Canary Islands. A short conclusion looks ahead to the future.

Astronomical Centers is a fresh, interesting way of looking at the rise of astronomy over the past two millennia. Anyone interested in this subject should certainly pick up a copy.

A Catalogue of Southern Peculiar Galaxies and Associations
Halton C. Arp and Barry F. Madore
Two vols., 482 pp., cloth, $125
Cambridge University Press,
New York, 1987

This important work by two of the most prominent names in extragalactic astronomy is a milestone in catalogues of deep-sky objects. The work is essentially an extension into the southern sky of the *Atlas of Peculiar Galaxies*, completed by Arp in 1966. This time Arp of Mount Wilson and his colleague Madore of the David Dunlap Observatory in Toronto inspected plates made with the 48-inch United Kingdom Schmidt telescope in Siding Spring, Australia. Arp and Madore worked on this project for fourteen years before publishing their results. The peculiar objects they found constitute *Southern Peculiar Galaxies*.

Volume I, the first 208 pages, is an extensive catalogue giving positions and brief descriptions of peculiar galaxies in the southern sky. The authors state that "the decision was made to limit the Catalogue to zones only as far north as a declination center of −25 degrees. Therefore the Catalogue is a complete listing of peculiar objects from the south celestial pole to a declination of −22 degrees."

Much information is provided for the galaxies. Among the types of galaxies included are those with interacting

companions, interacting triples, quartets, and quintets, M51 types, multiple-armed spirals, chains of galaxies, dwarf galaxies, stellar objects with associated nebulosity, and close pairs and triples. The catalogue lists identifications, positions in epoch 1950 coordinates, galactic coordinates, supergalactic coordinates, descriptions, sizes in arcminutes, and a plate reference number.

The second volume is a beautiful photographic atlas of some of the galaxies listed in the catalogue. Altogether, 1,017 negative images representative of the various types of peculiar galaxies appear in this volume. The photographs are remarkably sharp (as are all photos made with the U.K. Schmidt) and the level of faint detail visible is incredible.

The examples seem endless. The image of clumpy, low surface brightness arms in Arp-Madore 0510-330 (in the section on peculiar disks) is a magnificent astronomical photograph. AM 1239-402 (in the peculiar arms section) is a wonderful example of a face-on, tightly wound spiral. There are great photographs of ring galaxies, interacting pairs, thin disk galaxies, and Centaurus A look-alikes — hundreds of them. The group showing galaxies with polar jets is one of the best assembled in any single book. I could go on, but I think you get the picture.

Eye on the Sky: Lick Observatory's First Century
Donald E. Osterbrock, John R. Gustafson, and W. J. Shiloh Unruh
295 pp., cloth, $25
The University of California Press, Berkeley, 1988

Eye on the Sky is the story of Lick Observatory from its founding in 1888 up to the present. The heavy emphasis is on the early years, when colorful characters like Edwin E. Barnard, James E. Keeler, and Sherburne Wesley Burnham worked over the tomb of James Lick inside the dome of the world's largest telescope.

The remarkable story of how Lick got started is enough to make you want to read this book. The situation has all of the trademarks of a modern-day drama, with Lick's family waging a battle over his money, an ex-Confederate sailor managing the trust, and in Edward S. Holden, an overbearing director no one, apparently, could stand.

Despite this melodrama, Lick Observatory attracted some of the freshest and best talent when it opened its doors and made enormously significant contributions to astronomy before being eclipsed by newer institutions. Of course the observatory continues to do astronomy today, and the book discusses recent work at Lick as well as the observatory's fascinating history.

Osterbrock and company's work is historical writing at its best. Thick with detail, stylistically massaged to keep the reader interested, and full of the "spirit of the past," this work will exist as one of the best popular books on astronomical history around.

The Dark Matter: Contemporary Science's Quest for the Mass Hidden in Our Universe
Wallace and Karen Tucker
254 pp., cloth, $16.95
William Morrow, New York, 1988

One of the hottest research problems in modern astronomy comes down to a single question: "Where's the missing mass?" *The Dark Matter* addresses this question and its relation to the formation, current state, and possible endings of the universe. The book is nontechnical yet contains a well-cast, factual story about how this single research question is related to so much about modern astronomy.

In the first chapter of this book the Tuckers explain that "there is a growing belief among astronomers that galaxies are embedded in massive clouds of dark matter — that what we see in the Milky Way Galaxy and other galaxies is only part of what really exists . . . The dark matter problem is so pervasive that the solution promises to revolutionize astronomy and cosmology."

It certainly does. If you are not familiar with the complexities of the dark matter question and want a readable introduction to the field, I suggest picking up a copy of *The Dark Matter*.

Night Sky Photography
H. J. P. Arnold
152 pp., cloth, 9.95 British pounds
George Philip, London, 1988

Night Sky Photography is a beginner's guide to photographing the sky, aimed at people with some experience in snapshot photography. Arnold lays the groundwork for the book by saying: "The pages of astronomy magazines are full of frequently beautiful and awe-inspiring pictures, many of which are not the work of professional astronomers but of amateurs. With rare exceptions, the pictures owe nothing to luck and everything to application and hard work."

The early chapters describe the sky with emphasis on the Sun, Moon, and planets. Beginning in chapter three Arnold gets down to business and outlines astrophotographic equipment, films, and procedures.

Chapters that follow describe photography of various types of objects, including the Moon, Sun, stars, planets, comets and aurorae, and "meteors, satellites, aircraft, and 'UFOs'." Each chapter contains a few photographs, mostly black and whites with a few color plates inserted here and there. Although the nuts and bolts information in *Night Sky Photography* is brief, the book constitutes a sound introduction to the field of astrophotography.

— *David J. Eicher*

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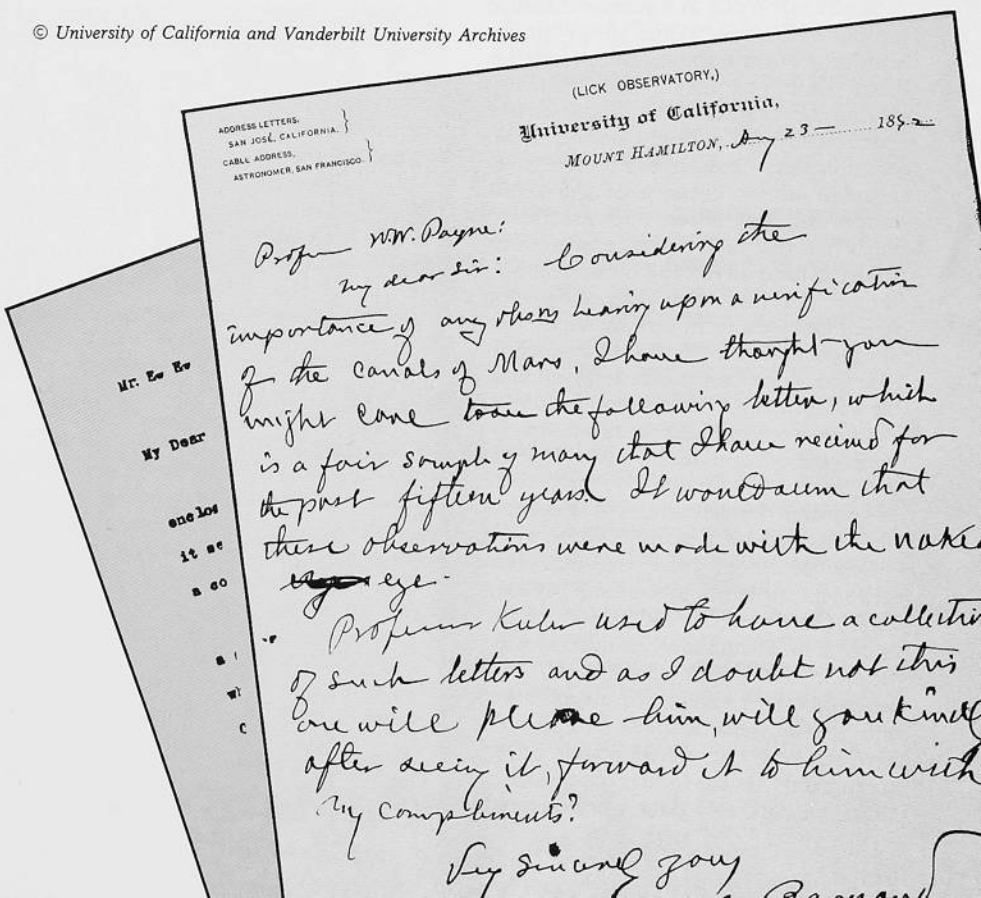

(LICK OBSERVATORY.)
University of California,
MOUNT HAMILTON, Aug 23 — 189.2
ADDRESS LETTERS: SAN JOSÉ, CALIFORNIA. CABLE ADDRESS, ASTRONOMER, SAN FRANCISCO.
Prof. W.W. Payne:
My dear sir: Considering the importance of any thing bearing upon a verification of the canals of Mars, I have thought you might care to see the following letter, which is a fair sample of many that I have received for the past fifteen years. It would seem that these observations were made with the naked eye.
Professor Kuhn used to have a collection of such letters and as I doubt not this one will please him, will you kindly after seeing it, forward it to him with my compliments?
Very sincerely yours

Double Stars

Two Summer Trapezia

by Brian Skiff

The Orion complex is the nearest region where massive, luminous stars are currently being formed. It would be exciting for astronomers (amateur and professional) if there were many of these regions available for contemplation or study. One would, of course, want to arrange them around the Milky Way so that one or more regions would be visible every season. And double star observers would prefer a tight knot of O- and B-type stars to shine in their centers.

Alas, like their earthly counterparts, exotic places are far away. There are indeed a number of O and B stars centered on star-forming regions distributed throughout the Milky Way, but none really rivals the 5th- and 6th-magnitude stars that comprise the Trapezium at the heart of the Orion Nebula.

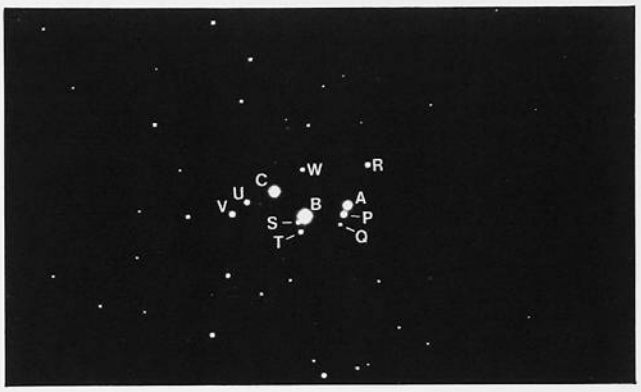
Two distant trapezia can be found in the northern summer Milky Way in the open clusters IC 4996 (Cygnus) and NGC 6823 (Vulpecula). The central groups are included in double star catalogues, although in each case ambiguities or outright errors appear.

Both clusters lie at a similar distance (about 2 kiloparsecs) and suffer similar amounts of obscuration by interstellar dust (about two magnitudes visually). While the brightest member stars are intrinsically just as bright as their Orion counterparts, they appear several magnitudes fainter because of sheer distance and the absorption associated with that distance. Despite being four times as far away as the Orion Nebula, these trapezium stars are not as close together as those in Orion, where the star density is the highest known. Still, many stars are compressed into an area no wider than the separation of Albireo. Both are a few million years old — very young but older than the Orion Trapezium stars — and consequently their primordial nebulae are now considerably thinned or absent.

Now let's look at the two open clusters as multiple star systems. IC 4996 is catalogued as ADS 13626 and bright enough to be included in the *Sky Catalogue 2000.0* Volume 2 (*SkyCat2*). The table here lists entries for eleven stars and gives identifications from both *SkyCat2* and the *WDS*, which differ inexplicably for the fainter components (details about how data were derived will be given below). I found the two previously unidentified entries in both catalogues to correspond unambiguously with stars relative to the B component.

IC 4996 was first measured as a multiple star by S. W. Burnham in 1876, almost thirty years before being "discovered" as an open cluster by Bellamy in 1903. Burnham's original measurements referred to the westernmost of the three bright components. Despite being listed generally as the brightest star, star A is actually by far the faintest of the three: it's nearly two magnitudes fainter than the conspicuous B component. Nevertheless, in the table I retain the original identifications to avoid further confusion. However, note that the magnitudes for all the stars are much better than those in *SkyCat2* or the *WDS*, which are as much as two magnitudes off.

In preparation for this article I viewed IC 4996 in my 6-inch apochromatic refractor from a dark site. At 30x the group was not at all conspicuous as an open cluster, but the central triangle was eye-catching in the very rich starfield. Switching to 80x, I found that averted vision showed many faint cluster members, whereas only the triangle and a few others were visible with direct vision. The effect was remark-



Open cluster IC 4996 photographed with the 61-inch astrometric telescope at the U.S. Naval Observatory in Flagstaff. Official U.S. Navy photograph.

IC 4996 Trapezium star B: 20 16 31.3 +37 38 31 (2000)

SC	WDS	Sep.	P.A.	V	B-V	MK	Remarks
A	A	—	—	9.72	0.39	B1IV	= BD+37°3859
a	P	4.20	154.3	11.0:	—	—	
b	Q	8.73	156.6	13.3:	—	—	
B	B	18.73	102.1	7.98	0.41	B0.2III	= HD193007 = BD+37°3860
d	S	BS: 3.97	129.2	12.6:	—	—	
e	T	BT: 6.87	162.4	11.6:	—	—	
C	C	AC: 31.74	77.0	8.99	0.37	B0V	= BD+37°3862
		BC: 16.79	48.7				
f	U	CU: 12.55	109.0	11.63	0.37:	—	
		BU: 25.46	74.1				this measure not identified on SkyCat2 or WDS
g	V	CV: 20.39	115.7	11.28	0.39	—	
h	W	BW: 19.89	0.7	12.64	0.45	—	this measure not identified in SkyCat2 or WDS
		CW: 15.19	305.4				
c	R	19.16	331.3	11.84	0.54	—	

Note: All separations and position angles are relative to star A unless otherwise noted. Photoelectric magnitudes and colors from van Schewick 1967 Veroff Astron. Univ. Bonn 76:35; MK types from Mermilliod 1976 Astr. & Ap. 24:159. F. A. Bellamy's "discovery" paper is in MNRAS 64:662.

able: an open cluster flashing on and off not unlike the famous "blinking" planetary NGC 6826, which is closeby to the northwest.

Because the faint companions to stars A and B were not clearly discernible at this power, I estimated Δm's for the three bright components. For BC I estimated 1.2, and for CA 0.75 (not really that precisely, merely "three quarters of a magnitude"). Later I found these estimates compared well with differences inferred from photoelectric measures: 0.99 and 0.73 respectively.

Finally, at 165x I counted about twenty stars within a 3.5-arcminute area. Only the brighter, closer companion to the A component was visible; the two companions to star B were discernible only as an elongated fuzz. Of the easily separable stars, component W about 20 arcseconds due north of star B was by far the most difficult.

Not many more cluster stars become visible with larger aperture, although the companions close to stars A and B are easier to resolve. A view two years ago through the U.S. Naval Observatory's 61-inch telescope showed the whole mess without trouble (as it should have!).

NGC 6823 is an easier object to view as a cluster but tougher as a multiple star. Again the table shows data for eleven components, but not all of these are included in the WDS entries for the cluster, which are ADS 12828, and Pourteau 4026, 4027, and 4028. ADS 12828 corresponds to visual measures by Jonckheere from 1911, while Pourteau measured plates for the *Astrographic Catalogue/Carte du Ciel* taken in 1892. All the measurements (magnitudes, separations, and position angles) are off in any case. Because of the large distance of these objects, no motion is expected, so the new measurements presented here better define the locations of the stars. Fortunately the cluster and trapezium have been well studied photometrically, so magnitudes are well in hand here.

In the 6-inch telescope at 50x the general aspect of the cluster was similar to IC 4996, but the surrounding field is not as dense, and the cluster is larger and contains more bright stars. At high power about thirty stars were visible including the central diamond-shaped trapezium. Only occasional glimpses were had of the other involved components — they are just too darn faint and closely packed for this aperture! Can someone with a 12- or 16-inch provide us with a more satisfying description?

Interestingly, the well-known guidebooks are quite lacking in their descriptions of these two objects: *Burnham's Celestial Handbook* omits IC 4996 and merely lists NGC 6823; Hartung and Webb skip them together; they are included in volume 3 of the *Webb Society Handbooks*, but the quoted observers used only low powers and so overlooked the special nature of the central trapezia.

The photographs of the clusters were taken at the USNO 61-inch telescope, which has a large scale that shows the compact clusters well; exposure details are provided in the captions. The IC 4996 plate is a "panchromatic" shot, while the NGC 6823 plate is a blue-light exposure. For stars without good magnitudes, I estimated V magnitudes by eyeball interpolation using stars in each field with photoelectric measures; the differing passbands of the plates should not introduce large errors since all the stars have similar B-V colors. I estimate their errors to be no more than ±0.15 for NGC 6823 but a little worse in IC 4996 because the photometric sequence is less evenly distributed in brightness. These estimated data are given in the table to 0.1 magnitude and marked with a colon.

The astrometric measurements were made on the same plates. The stars were scanned on the Lowell PDS microdensitometer, which yielded positions of the star centers to a precision of 1 micron or better. For separations I used the well-established value (13.55 arcsecond/millimeter) for the image scale of the Navy 61-inch. To get position angles, I assumed that the plates were exposed orthogonally with respect to cardinal directions on the sky and that the PDS measuring stage was similarly squared-on. These assumptions appear to be valid within a fraction of a degree in position angle based on measurements for a few of the stars contained in astrometric star catalogues. Ideally, the plates should have included a trailed exposure so that the east-west direction could be precisely established.

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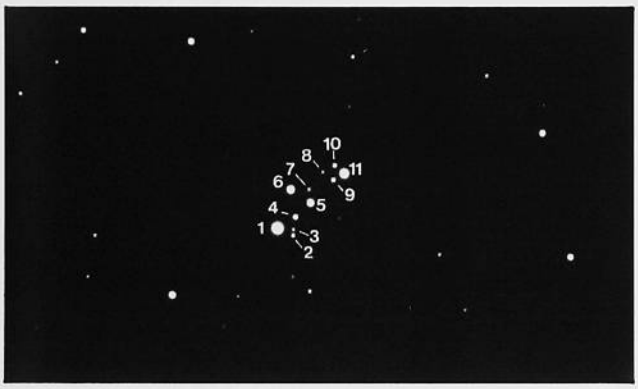


Open cluster NGC 6823 photographed with the 61-inch telescope at Flagstaff's Naval Observatory. Chris Luginbuhl made both of these plates. Official U.S. Naval Observatory photograph.

NGC 6823 Trapezium Star 1: 19 43 10.9 +23 17 46 (2000)

Star	Sep.	P.A.	V	B-V	MK	Remarks
1	—	—	9.34	0.56	07V(f))	= HD344784
2	7.29	244.5	13.2:	—	—	
3	6.81	264.3	13.6:	—	—	
4	8.99	301.1	12.13	0.50	b5v	= Pou 4026: 9".7; 303
5	17.70	306.9	11.07	0.44	B1.5:V	= Pou 4027: 18".4; 307
6	17.41	340.4	10.96	0.25	B1.5V	= Pou 4028: 17".7; 340
7	21.36	320.1	13.55	0.38	b8v	
8	30.76	320.3	13.90	0.56	b5v	
9	31.51	309.9	12.6:	—	—	= ADS 12828B: 5".40; 119.7 (Jonckheere's 1911 measure: 3".0; 107)
10	36.26	316.7	12.87	0.45	b3v	= ADS 12828C: 5".33; 48.7 (Jonckheere's 1911 measure: 4".4; 48)
11	36.84	308.4	9.97	0.69	O7V(f))	= ADS 12828A

Note: Spectral types in lower case are inferred from $(B-V)_0$ given by Turner 1979 JRASC 73:74, which is also the source for V, B-jV, and MK types.

Variable Stars

Have Yourself a Cataclysmic Day

by David H. Levy

As summer's warmth, vacations, bugs, and outdoor fun descend upon us again, I wonder why more deep-sky observers don't turn their attention to variable stars — especially the ever-fascinating cataclysmic stars.

If you read the summer 1986 column, you've seen a mention of 213843 **SS Cygni**. This is a variable star that erupts and brightens by about four magnitudes once every six or seven weeks (roughly a 40x increase) before dropping back to its normal brightness. SS Cygni is a very easy star to observe and lies far enough north to be visible much of the year. Summer, though, is its best season because the star is high in the sky all night.

Astronomers know of about 250 cataclysmic variables, which are also called dwarf novae and U Geminorum stars. These stars characteristically remain at some minimum luminosity for weeks and then suddenly brighten. SS Cygni itself spends much of the time at about magnitude 12.1. Abruptly it climbs to a magnitude 8.2 or 8.3 maximum, remains there a few days, and then declines slowly over a week or so.

John Griese, a variable star observer from Connecticut, has watched the ups and downs of SS Cygni since 1973. He recalls one minimum that lasted almost two months and another that lasted less than one. Although most of the maxima he has seen reach magnitude 8.3 and last the better part of a week, he has occasionally seen "spike" maxima lasting but two or three days in which the star climbs only to about magnitude 10.5.

Like all its cataclysmic cousins, SS Cygni is a binary star system made up of a small white dwarf in close proximity to a larger cool star — the distance between them may be no more than the diameter of the larger star. In such a system both stars experience strong tidal forces, but because the extended outer atmosphere of the cool star is attached loosely, this star sheds material continually. As it streams off the larger star, the gas swirls around in the system and ends up forming a disk that rings the white dwarf. As more and more material falls onto the disk, it creates a hot spot or region where intermittent fusion reactions can "touch off" the accumulated material and release enough energy to brighten the star explosively.

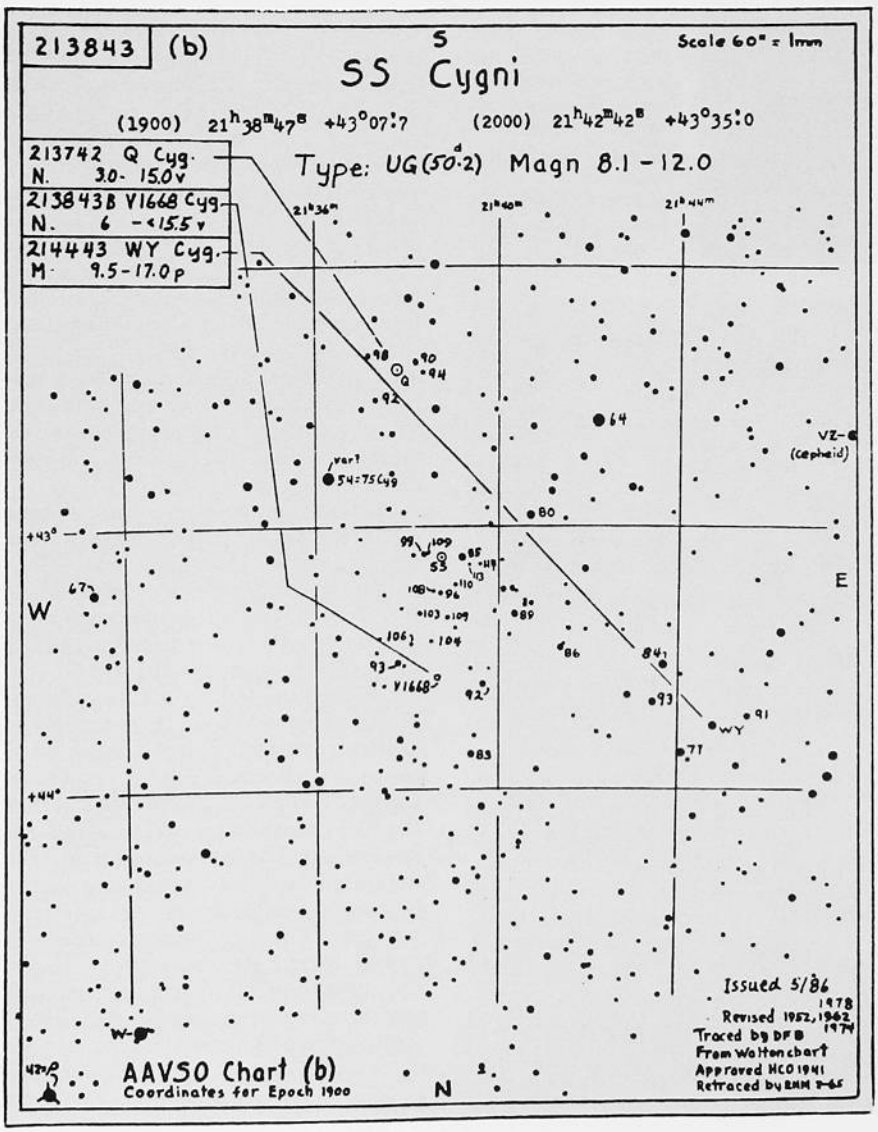
While SS Cygni is the most famous of the summertime cataclysmics, others beckon too.

094512 **X Leonis**. Early in summer you may catch X Leonis west of the meridian and on its way down to the horizon. Extremely easy to find, it practically touches 6.6-magnitude 21 Leonis and lies just 1′ east (and slightly north) of the famous Mira-type variable R Leonis.

The problem with observing X Leonis is that its minimum lies at about magnitude 15.5, deep in the realm of large telescopes. But this doesn't mean you can't observe the star with a smaller telescope. Its outbursts (roughly every 23 days) bring it up to magnitude 11.5, bright enough to view comfortably with an 8-inch instrument. As long as you are willing to "view" it many times (and see nothing at its position), you can patrol for its outbursts with even a medium-size scope.

174406 **RS Ophiuchi**. This isn't a dwarf nova but a recurring one — its period is measured in years rather than weeks. Its 1985 outburst was discovered by Warren Morrison, an active Canadian observer from Ontario. Previous outbursts occurred in 1967, 1958, 1933, and 1898. Much of the time RS Ophiuchi sits at its minimum magnitude of 11.8; its maxima can be as bright as magnitude 4.3 and as dim as 6th magnitude. But even at minimum brightness, RS Ophiuchi can change by as much as a full magnitude. Find the star by sweeping about 4° southwest of 4.6 magnitude Zeta (ζ) Serpentis.

184137 **AY Lyrae**. This star poses more of a challenge to observe than



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most in this list, because it has a maximum of only 12.6 and a minimum that lies below 16th magnitude. The period is about 24 days. Situated less than half a degree from Zeta (ζ) Lyrae, AY Lyrae is easier to locate than to estimate because the star is so faint most of the time.

192150 **CH Cygni**. This is a symbiotic variable, a system with a basic structure similar to the cataclysmics: a small, hot white dwarf and a large cool companion. But here the big cool star is losing gas into a shell that may surround both stars. In some symbiotic variables the cool star undergoes the large and leisurely changes typical of Mira stars. In addition the gas shell can vary in thickness, which also causes light changes, and the small star can vary its brightness too! (You can even get eclipse phenomena in systems if the orbital geometry happens to be right.)

In the case of CH Cygni the large star is a semiregular pulsating red giant. It is possible that the disk around the white dwarf forms only when the giant star is at maximum light (and most distended). For observers, the CH Cygni system is basically a bright, red, semiregular variable that's tailor-made for viewing with binoculars or small telescopes. Its 1.5-magnitude range, from 6.6 to 8.0, is not hard to follow. While its nominal period is 97 days, given all that's going on in this star system, the period isn't easy to decipher. Expect surprises!

005840 **RX Andromedae**. Also a candidate for the later hours of the night, this Z Camelopardalis star ranges from magnitude 13.6 at minimum to 10.6 at maximum and is located conveniently just 4° east of M31, the Andromeda Galaxy. Look about a third of a degree east and slightly south of 6th-magnitude 39 Andromedae. Its period is approximately 14 days when it isn't in a standstill.

080362 **SU Ursae Majoris**. Located at a high declination and visible essentially all year long, SU Ursae Majoris is a very special U Geminorum star. It ranges from 14.5 at minimum to 11.0 at maximum, and while its period averages 17 days, like most U Geminorum stars, this varies considerably. The nicest thing about SU Ursae Majoris is that every few outbursts the star displays a "super maximum," in which the star's peak brightness may climb a full magnitude higher than usual and the star remains in outburst longer than normal.

* * *

How often should you observe a cataclysmic variable? The real answer is every clear night. Now obviously this is impossible, even for the most diligent observer in the world. The trick with these stars, however, is to keep enough of them under observation that you stand some chance of catching at least one of them in outburst on the occasions you can observe.

When you observe a star that has a minimum brightness below your telescope's limit and you see nothing where the star should be, note in your logbook the magnitude of the faintest star visible in the immediate field. If the faintest star you can see is magnitude 13.3, note the variable as "(13.3". This way you are still making a contribution because your "fainter than" report indicates the star wasn't undergoing an outburst at that time.

Charts with comparison magnitudes are available for a small fee from the AAVSO, 25 Birch Street, Cambridge, MA 02138. Write for details on how to order and include a self-addressed, stamped, long envelope.

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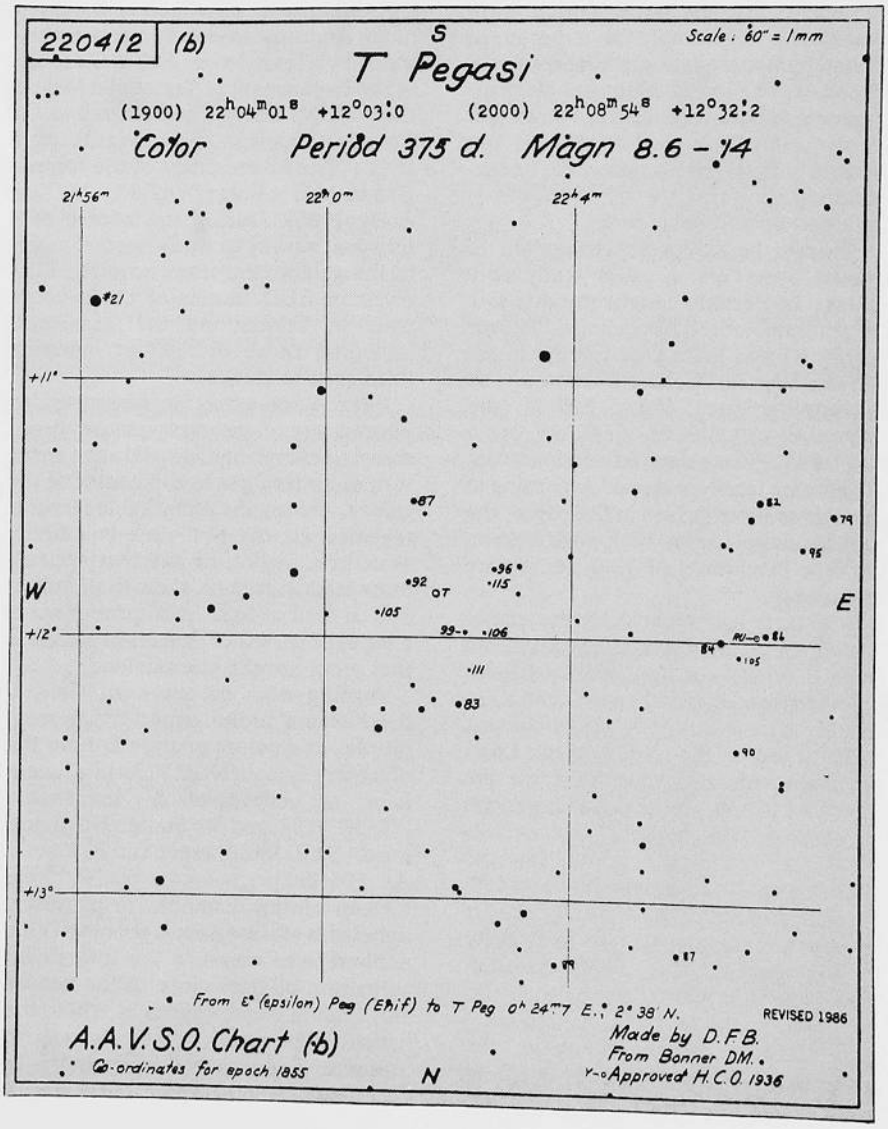
Summertime Cataclysmic Variables

Name	R.A. and Dec.	Range	Period (d)
005840 RX And	1h04.6m +41°18′	13.6-10.3	14
080362 SU UMa	8h12.5m +62°37′	14.5-11.0	17
094512 X Leo	9h51.0m +11°53′	15.5-11.5	23
164025 AH Her	16h44.2m +25°15′	9-14	20
174406 RS Oph	17h50.2m −6°43′	11.8-4.3	(many years)
184137 AY Lyr	18h44.4m +38°00′	16-12.6	24
192150 CH Cyg	19h23.6m +50°14′	8.0-6.6	97
213843 SS Cyg	21h42.7m +43°35′	12.1-8.2	dM2
220912 RU Peg	22h14.1m +12°42′	13.1-9.0	70

(Positions are for epoch 2000.0; all periods are approximate.)



Scanning the Literature

January-March 1988

by Brian Skiff

Results from the long-running Asiago Observatory Supernova Search are summarized by E. Cappellaro and M. Turatto ("A New Determination of the Frequency of Supernovae," *Astronomy & Astrophysics [AA]* **190**:10). Since 1969 about seventy fields of galaxies have been monitored with 16-inch and 26-inch Schmidt cameras: fifty-one supernovae have been detected since this time.

Combining the data for all types of galaxies in the sample, the supernova rate is about once in every 230 years (± about forty years) for the more luminous type I events, and once in every 370 years for type II events, which is a combined rate of once per 143 years.

These rates are similar to results mentioned in the last issue, which were based on the sample of supernovae found by Robert Evans in Shapley-Ames galaxies. The implications are clear for amateur supernova hunters: You cannot look at only a handful of galaxies and expect to find anything soon. To be successful, you must survey hundreds of galaxies on a regular basis.

Despite being largely irrelevant to visual observers, a radio study of a galaxy in Perseus caught my eye in a recent issue of the *Astronomical Journal [AJ]* ("HI and Mass Distribution in the Dwarf 'Regular' Galaxy UGC 2259" by Claude Carignan, Renzo Sancisi, and Tjeerd S. van Albada, *AJ* **95**:37, January 1988). The galaxy is a low surface brightness late-type spiral. According to measures summarized in the paper, the total B magnitude is 13.4, with a mean surface brightness of 15.0 per square arcminute.

A figure accompanying the paper shows the inclined spiral in a starry field with — what? — a high surface brightness compact elliptical and — oh no! —a double star. Even though the field was already low in the west at dusk, I had to check this out visually. I set the Lowell 21-inch photometric telescope on the position (2000: 2h47m55.2s +37°32'21") and immediately saw the double star. As complete darkness fell, the diffuse spiral and nearly stellar compact companion (listed by Zwicky as photographic blue magnitude 15.6) also came into view. Despite their differing sizes, the galaxies seemed similarly bright overall. Through the high-powered "post-viewer" eyepiece of the photometer, the small galaxy was about 20" across and broadly concentrated.

The double star (ADS 2130) is listed in the *WDS* with magnitudes of 10.5 and 10.7. However, one look in the eyepiece was enough to see that the magnitude difference was not so small, more like a full magnitude. I thought, well, hell, I am looking through a photometer, so let's just measure them! After taking some quick integrations, I found that the combined magnitude of the pair is about V = 9.9, and the Δm is 0.96; the individual magnitudes are thus V = 10.3 and 11.2. Interestingly, the stars are separating because of the proper motion of the primary, which amounts to about one tenth of an arcsecond per year —an optical pair. They are now about 9" apart, aligned roughly east-west.

Users of large telescopes (a 12-inch from a dark site should do the trick) should be able to pick up this disparate trio.

A remarkable new look at the bulge of the Andromeda Galaxy has been provided by a team led by Robin Ciardullo of the Department of Terrestrial Magnetism (which hires astronomers!) at the Carnegie Institution in Washington, D.C. ("The Morphology of the Ionized Gas in M31's Bulge," *AJ* **95**:438, February 1988). During the course of a five-year survey to study normal novae in the galaxy, the team acquired hundreds of CCD frames of the galaxy's core in several narrow passbands including those of nebular emission lines seen in novae.

After a massive image-processing effort a set of mosaics was produced showing exceptional detail in the structure of ionized gas in the center of the galaxy. Among the remarkable features revealed for the first time is a finely structured region of gas that appears more nearly face-on than the familiar optical disk of M31. Also prominent is a series of very thin threads of emission that wind around the nucleus.

Turning now to our own Galaxy, there was a useful paper giving magnitudes and colors of stars around the planetary nebula NGC 7139 in a recent issue of *Astronomy & Astrophysics* ("NGC 7139 and Its Stellar Neighborhood" by R. Weinberger and R. Ziener, *AA* **191**:297).

Determining distances to planetary nebulae is still a difficult problem. One method is to measure the interstellar extinction of stars close to the nebula and finding the distances at which the nebular extinction (relatively easy to measure) matches that of the stars. In this report, photographic UBV magnitudes and objective-prism spectral types (from which absolute magnitudes are inferred for the stars) were obtained.

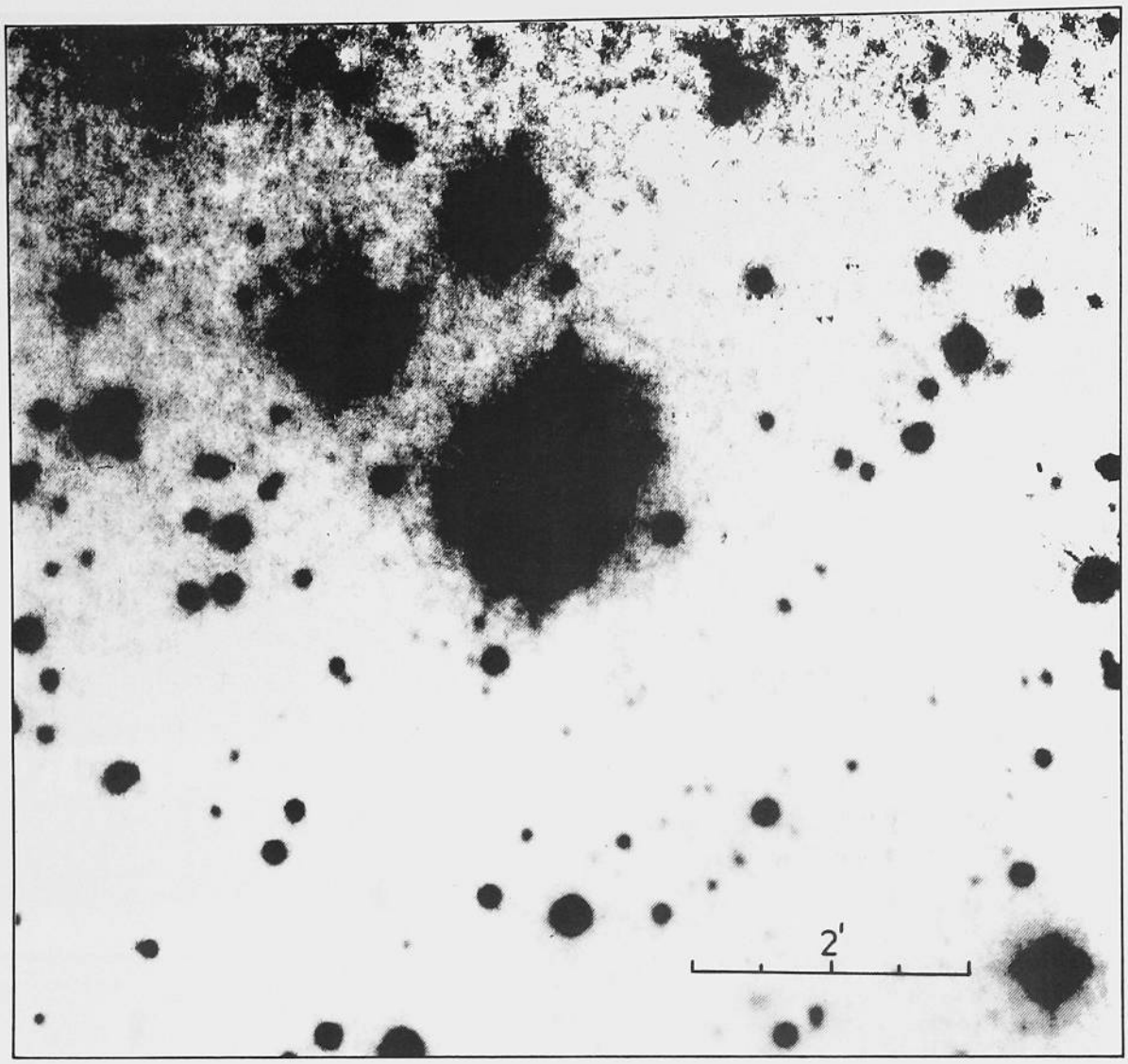
The distance determined was 2.4 kiloparsecs, with an error of ± 0.7 kpc — this is not an exact method by any means. Nevertheless, the paper includes a chart and magnitudes for many stars within 15" of the nebula; these can be useful for calibrating both visual and photographic observations. The stars range from V magnitude 12.4 to 16.2.

A similarly useful article concerning a 9th-magnitude globular cluster in Puppis has also been published ("NGC 2298 –Another Perfectly Normal Globular Cluster in the Outer Halo" by Kenneth A. Janes and J. N. Heasley. *AJ* **95**:762, March 1988). The authors provide a new color-magnitude diagram based on deep CCD exposures. Unlike nearly all CCD studies, this paper actually includes results for brighter stars as well as a new sequence of bright field stars measured photoelectrically. The "local" standards (identified on an excellent photo of the cluster) range from V magnitude 9.9 to 16.7.

Incidentally, the distance found for the cluster is 12.4 kpc; the brightest stars are magnitude 13 and the cluster can be resolved in an 8- to 10-inch telescope from northern skies.

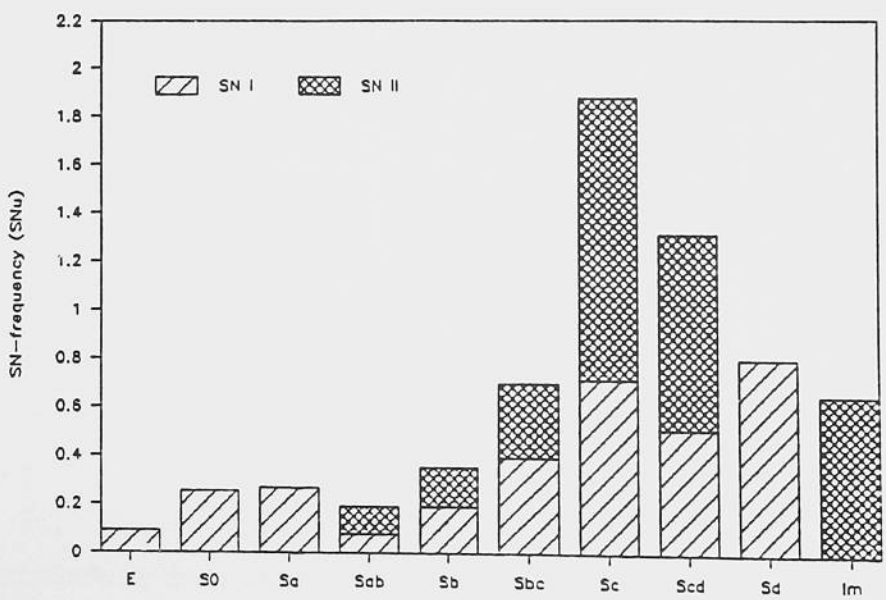
A detailed analysis of the structure of the structure of 47 Tucanae has been published, including the best available estimate of the diameter of this bright globular ("Studies of Dynamical Properties of Globular Clusters IV. Detailed Structure of 47 Tucanae" by G. Meylan, *AA* **191**:215). The author summarizes all published aperture-photometry of the cluster and fits a large number of numerical models to the data. The relatively concentrated cluster (Shapley-Sawyer concentration class III) has a total diameter of 100' (1-2/3°); this is the distance at which member stars are balanced between being bound to the cluster and stripped away by other forces in the Galaxy. The angular distance corresponds to 60 pc; models with varying structure, mass, and density that fit the observations well indicate "tidal" diameters ranging between 54 and 67 pc.

Finally, I'd like to mention a commentary that appeared in the 11 February 1988 issue of *New Scientist,* a British science news magazine. In it astronomer Tony Jones takes us to task for perpetuating to the public the myth that astronomers reckon large distances in light-years. This has been untrue at least since the speed of light was measured precisely by Michelson and



Above: A section of the Palomar Observatory Sky Survey *shows the dwarf galaxy UGC 2259 and two companion objects in the same telescopic field. Just north of UGC 2259 is a small elliptical galaxy; to the northeast lies the 10th-magnitude double star ADS 2130.*

Below: With 16-inch and 26-inch Schmidt cameras, Italian astronomers E. Cappellaro and M. Turatto produced this histogram showing the frequency of supernova events versus galaxy type. Sc galaxies clearly outnumber all others in producing supernovae.



Morley just one hundred years ago. Jones argues that no human has any conception of how far a light-year (or the proper unit, a parsec) is, and so we should always resist the urge to convert parsecs to light-years when writing or speaking to lay audiences about astronomical distances.

He suggests journalists are in the best position to "put an end to the hoax" but foresees that we may need some reassurance, given that we've followed along with it so long. He imagines this enlightened conversation:

Journalist: . . . and just how far away is this supernova?

Astronomer: Oh, it's . . . uh . . . let's see, fifty-two times three-and-a-bit, that's . . . um . . .

Journalist: That's all right, Dr. Zenith, you don't have to talk in light-years. I'm a man/woman of the world, why don't we use the proper words?

Astronomer: Well, then, it's about fifty-two kiloparsecs. Gosh! I said it! You know, I've been living a lie for years. Thank God someone understands!

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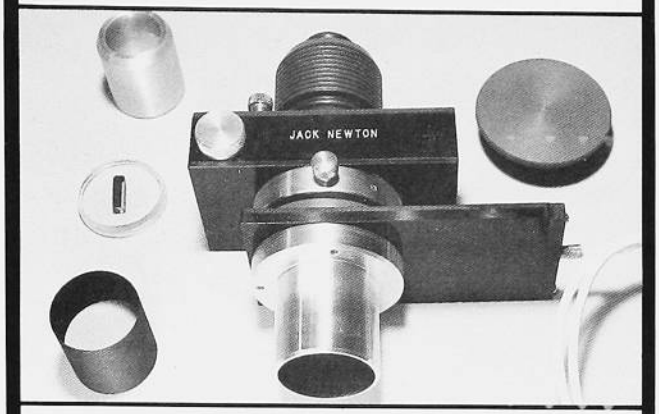

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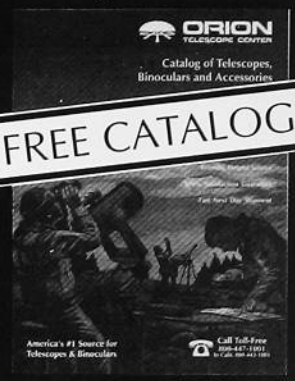

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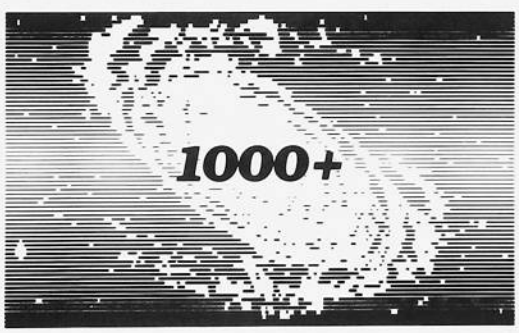

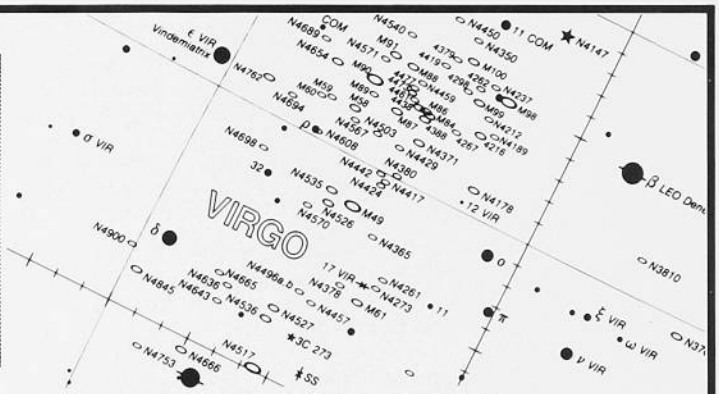

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#419 Illuminated Reticle Eyepiece only (1¼")	$78
#126 2X Telenegative Amplifier (2045, 2045/LX3)	$39
#122 2X Telenegative Amplifier (for all 8" & 10" Schmidt-Cassegrains)	$39
#127 2X-3X Variable Teleneg. Amp. (for all 8" & 10" Schmidt-Cass)	$49
#140 2X Telenegative Amplifier (for all 8" & 10" Schmidt-Cassegrains)	$64
Photo-Visual Color Filter (1¼") thread-in: #8 Light Yellow, #11 Yellow-Green, #12 Yellow, #21 Orange, #23A Light Red, #25A Red, #47 Violet, #58 Green, #80A Blue; each	$11.95
Color Filter Polarizer (30% transmission) (1¼") thread-in	$11.95
Set of 6 Photo-Visual Color Filters (1¼"): (#8, #23A, #58, #80A, 2 polarizers)	$69
#905 Variable Polarizing Eyepiece System (1¼")	$39
Series VI Drop-in Filter Set (#1A Skylight, #8 Light Yellow, #11 Yellow-Green, #25 Red, #80A Blue, Neutral Density ND4)	$42
#1A Skylight Filter/Dust Seal	$38
#908 Nebular Filter (1¼"), thread-in	$59
#910 Nebular Filter (2")	$89
#911 Nebular Filter (rear cell thread-on)	$98
#582 Dew Shield (4") (2045, 2045/LX3)	$44
#712 Dew Shield (8") (for Meade 8" Schmidt-Cassegrains)	$56
#710 Dew Shield (10") (for Meade 10" Schmidt-Cassegrains)	$84
#62 T-Adapter (basic camera adapter)	$28
T-to-C 16mm Movie/Video Camera Adapter	$28
Tele-extender	$25
Piggyback Bracket (2045, 2045/LX3)	$17
Piggyback Bracket (for Meade 8" Schmidt-Cassegrains)	$29

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Mounting Bracket only for Model 2048	$169
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Deluxe Latitude Adjuster (2045, 2045/LX3)	$26
Setting Circle Illuminator System (for Meade 8" Schmidt-Cass)	$35
Setting Circle Illuminator System (for Meade 10" Schmidt-Cass)	$35
#36 Single-Axis/Dual Axis Drive Corrector Control Box (2045/LX3, 2080/LX3)	$85
#38A Electric Declination System (2045/LX3)	$78
#38 Electric Declination System (2080/LX3)	$78
#39 Electric Declination System (2080/LX5, 2120/LX5)	$80
#43 R.A. Drive Corrector (Operates from 12V D.C.) (2045)	$78
#1200 Electric Focuser (2045, 2045/LX3, 2080/LX3)	$129
#1200A Electric Focuser (2080/LX5, 2120/LX5)	$119
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#1401 Tube Balance Weight System (for Meade 8" Schmidt-Cass)	$74
#1402 Tube Balance Weight System (for Meade 10" Schmidt-Cass)	$79
Extra 2-lb. Weights for #1401 or #1402, each	$14
#600 Power Cell with battery pack & recharger (2080/LX3, 2080/LX5, 2120/LX5)	$120
#607 25' Extension Cord for use with AC converter (2080/LX3, 2080/LX5, 2120/LX5)	$18
L.E.D. Map Light (2045/LX3, 2080/LX3)	$24
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4" Fork Mount only (as included with 2045)	$375
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8" Fork Mount only (as included with 2080/LX5)	$749
10" Optical Tube Assembly only (includes 10" f/10 optical tube assembly, dust covers, carrying case)	$999
10" Fork Mount only (as included with 2120/LX5)	$899
#2081 8" Schmidt-Cassegrain Spotting Scope with 6x30 viewfinder, 1¼" eyepiece-holder, MA 25mm eyepiece (80X), MA 9mm eyepiece (222X), #924 erecting prism, ¼-20 tripod adapter, carrying case	$649
Spotting Scope Adapter Plate (for Meade 8" Schmidt-Cassegrains)	$39
Spotting Scope Adapter Plate (for Meade 10" Schmidt-Cassegrains)	$49
Optional Systems for Previous Meade 8" & 10" Schmidt-Cass. Models: Equatorial Wedge (for Meade 8" Schmidt-Cassegrains)	$75
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#967 9x60mm Polar Illuminated Viewfinder with Bracket (for Meade 8" & 10" Schmidt-Cassegrains)	$139
#36 Single-Axis/Dual-Axis Drive Corrector Control Box (2120/LX3)	$79
#38 Declination Motor Assembly (2120/LX30)	$79
#38B Declination Motor Assembly (2080, 2120 only)	$79
#600 Power Cell with Battery Pack & Charger (2120/LX3)	$125
#1200 Electric Focuser (for all 8" & 10" Schmidt-Cassegrains *except* Models 2080/LX5 & 2120/LX5)	$129
#419 Illuminated Reticle Eyepiece System (1¼") with #702A Double Crossline Reticle	$79
#427 Illuminated Reticle Eyepiece System (.965") with #702A Double Crossline Reticle	$79
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#702A Double Crossline Reticle	$20
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Alternate 1¼" Barrel for #427	$10
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#43 R.A. Drive Corrector (12V DC only)	$78
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#54 Accessory Case (8" x 12" x 3¾")	$18
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#280PG 2.4" Photo-Guide Telescope	$119
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